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TEMPERATURE PROFILES OF TRUCK TRANSPORTED ORDNANCE

by

Billy D. Martin
and
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Propulsion Development Department

ABSTRACT. Temperatures experienced by truck transported ordnance during severe hot and cold weather conditions have been measured. The measurement methods and data are documented.

The temperature profiles of typical ordnance items are plotted and show that the ordnance items do not experience the extreme measured ambient air temperatures.

NAVAL WEAPONS CENTER
CHINA LAKE, CALIFORNIA * JUNE 1970

76

NAVAL WEAPONS CENTER

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M. R. Etheridge, CAPT, USN .... Commander

H. G. Wilson .... Technical Director (Acting)

FOREWORD

This effort was undertaken during CY 1969 to determine the valid thermal exposure environment for truck-transported ordnance. This work was supported by the Naval Air Systems Command Environmental Criteria Determination Problem Assignment Number NAVAIR 0330/216/F 19.332.301.

This report has been reviewed for technical accuracy by Warren W. Oshel.

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The authors wish to thank Lloyd Rodgers, John Scarbrough, James Roney, Paul Lewis, Henry Green, William Giuliane, and Alfred Stevens of the Ordnance Division, Code 255 for their cooperation and assistance in obtaining the measurements reported herein.

Two of these personnel deserve a special note of appreciation. John Scarbrough was the driver during the cold weather measurement series. This portion of the measurement series was completed because of his cool head in emergency situations and his extreme skill and dedication. It should also be mentioned that this is not the first measurement series in which Mr. Scarbrough's efforts have been a vital factor to successful completion.

James Roney was the driver during the hot weather measurement series. Because of his dedication, skill, and ability to make decisions under extreme conditions, the required measurements were obtained.

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INTRODUCTION

Maximum and minimum temperature limits for truck-transported ordnance have, in the past, been assigned purely on the basis of meteorology. However, it is unreasonable to assume that the ordnance temperatures change as rapidly or reach temperatures as extreme as the environment. This is primarily due to the slow response of the ordnance to changes in air temperature (thermal lag) and the damping effect of the diurnal cycle.

The minimum and maximum ordnance temperatures depend on several thermodynamic driving forces. Generally, an item of ordnance will not exhibit the same skin or internal temperature as the surrounding air, and in most cases, will not reach equilibrium at the same temperature.

Evaluating environmental conditions to determine realistic limitations of ordnance thermal exposure relative to in-Fleet operations is a continuing program. As part of this, the Environmental Criteria Determination Section, Code 45330 at the Naval Weapons Center (NWC), China Lake, California, is developing temperature profiles for truck-transported ordnance. In order to obtain temperature measurements for development of these profiles, a standard Navy ordnance truck was loaded with typical ordnance items and routed through areas known to experience extreme hot and cold temperatures. This report covers the results of that work. Also presented is a sample of data from trucks located in particular areas of interest for continuing measurements.

DISCUSSION

EQUIPMENT AND ORDNANCE LOAD

Since it was stipulated that any measurement of ordnance transportation should be accomplished using standard Navy equipment and certified ordnance drivers, a standard ordnance certified 2-1/2 ton van truck (Fig. 1) was obtained from the Ordnance Division of NWC. The truck was loaded with a weight-limited load of common items of Naval Ordnance. Figure 2 shows the inside of the truck with the full load for the cold-weather run. The load consisted of a pallet of 5-inch Naval projectiles, a pallet of 105mm Howitzer projectiles, a half pallet of Mk 82 500-pound low drag bombs, a Zuni missile motor, a Sparrow missile motor, and an ASROC missile motor. All items were blocked against movement per normal ordnance hauling procedures.

FIG. 1. Standard Ordnance Van.

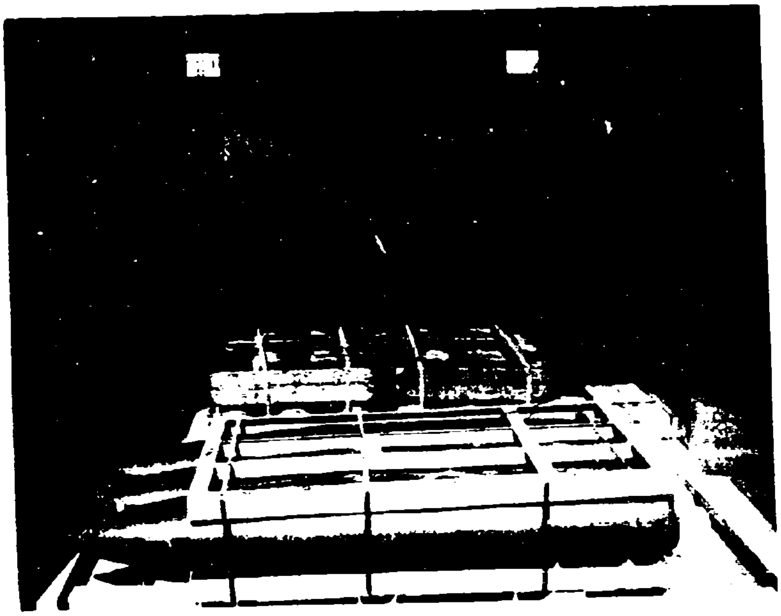


FIG. 2. Ordnance Load for Cold-Weather Run.

INSTRUMENTATION

Inverter

The ordnance van was equipped with a Terado Model 50-191, solid-state, 275 W, 12 VDC to 110 VAC, 60 cps inverter (Fig. 3). The unit, mounted under the hood close to the battery, supplied 100 W power to run a Minneapolis-Honeywell Model 15 Universal recorder. During overnight stops on the cold-weather run, the recorder was operated directly from an extension cord plugged into a 110-volt receptacle. The same inverter was used for power on cold- and hot-weather runs.

FIG. 3. 12 VDC to 110 VAC Inverter Installation.

Thermocouples

The thermocouples used for sensing functions were standard copper-constantan, with thermocouple-grade wire from sensor to recorder. A fiberglass-over-asbestos insulation was chosen so that the combination of low temperature and vibration would not break the insulation and allow the wires to short-circuit. The asbestos individually insulated wires and the fiberglass protected the asbestos; this prevented development of false sensing-junctions. Therefore, the sensing junctions for all reporting thermocouples were known.

Thermocouple placements for the cold-weather run are shown in Fig. 4. Ordnance used for the hot-weather measurements was the same as for cold, with the Sparrow missile motor deleted. Comparison of cold-weather road measurements indicated that some channels of information were redundant. Therefore, thermocouples were located as shown in Fig. 5 for the hot-weather runs.

Recorder

From the start of the cold-weather run until final return to China Lake, the recorder was in constant operation measuring air and ordnance temperatures. Before installation in the van for cold measurement (see Fig. 2), the recorder was thoroughly checked, winterized, and calibrated in the NWC instrument shop. This instrument system will not function properly when soaked to below-zero temperatures without winterization. Calibration was checked daily by a technician during the cold-weather run. The recorder was rechecked in the instrument shop at the conclusion of the measurement sequence. Thus the instrument was known to be accurate within 1/4 of 1% (full scale), or less than ± 1°F.

The sampling rate of the 24-channel instrument was 30 seconds per print. Each of the 24 channels was sampled every 12 minutes during each 24-hour day of the cold-weather run.

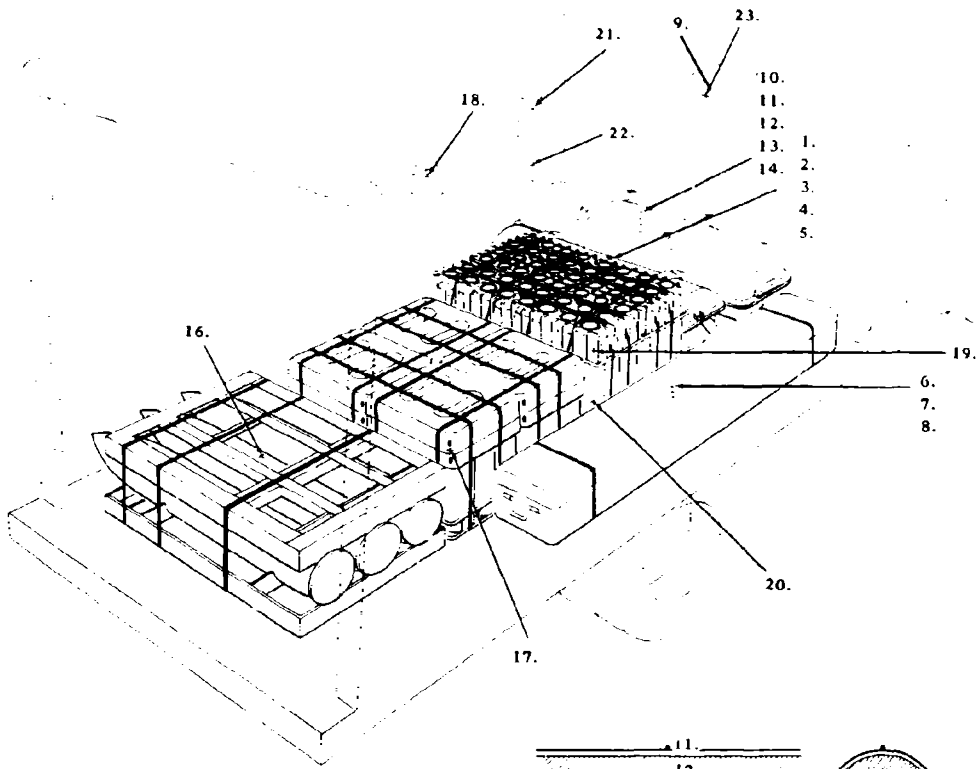
For the hot-weather runs, the recorder was thoroughly checked and calibrated in the instrument shop to insure accuracy before installation in the van. The recorder was also checked thoroughly while operating on truck (inverter) power to insure against stray voltage interference. Calibration was checked before departure each day. It is known, therefore, that the recorder was within specification tolerance.

The sampling rate, because channels were deleted from the matrix, was 30 seconds per print for 12 channels. Each channel was sampled once every 6 minutes continually during each daily run.

MEASUREMENT-SEQUENCE ROUTING

Cold-Weather Run

The cold-weather, moving vehicle situation was explored during winter, 1969--the most extreme winter weather in western United States since 1952, and for some aspects, since 1937. Winter temperature extremes were sought out, on a planned 4,000-mile route through regions known to experience severely low temperatures. The course was deliberately altered enroute (within planned limits) to expose the ordnance-loaded van to representative frigid or stormy weather. Temperatures were continuously recorded as the van was driven through storms along the general routing.



1. CENTER STAR OF SPARROW MISSILE MOTOR
2. CENTER STAR OF SPARROW MISSILE MOTOR
3. OUTSIDE OF CYLINDER GRAIN OF SPARROW MISSILE MOTOR
4. INSIDE OF SHELL GRAIN OF SPARROW MISSILE MOTOR
5. OUTSIDE OF SHELL GRAIN OF SPARROW MISSILE MOTOR
6. AIR INSIDE OF ZUNI MISSILE MOTOR CONTAINER
7. SKIN OF ZUNI MISSILE MOTOR
8. CENTER OF GRAIN OF ZUNI MISSILE MOTOR
9. AIR TEMPERATURE OUTSIDE OF VAN
10. AIR TEMPERATURE INSIDE OF ASROC MISSILE MOTOR
11. OUTSIDE OF ASROC MISSILE MOTOR WALL
12. INSIDE OF SHELL GRAIN OF ASROC MISSILE MOTOR
13. CRUCIFORM GRAIN OF ASROC MISSILE MOTOR
14. WALL OF ASROC MISSILE MOTOR CONTAINER
15. RECORDER
16. SKIN OF MK 82 LOW-DRAG BOMB
17. SKIN OF 105mm HOWITZER PROJECTILE, RIGHT REAR OF PALLET
18. SKIN OF 105mm HOWITZER PROJECTILE, LEFT FORWARD OF PALLET
19. TOPSKIN OF 120mm AA PROJECTILE, RIGHT REAR OF PALLET
20. BOTTOMSKIN OF 120mm AA PROJECTILE, RIGHT REAR OF PALLET
21. TOPSKIN OF 120mm AA PROJECTILE, LEFT FORWARD OF PALLET
22. BOTTOMSKIN OF 120mm AA PROJECTILE, LEFT FORWARD OF PALLET
23. AIR TEMPERATURE INSIDE OF VAN
24. RECORDER

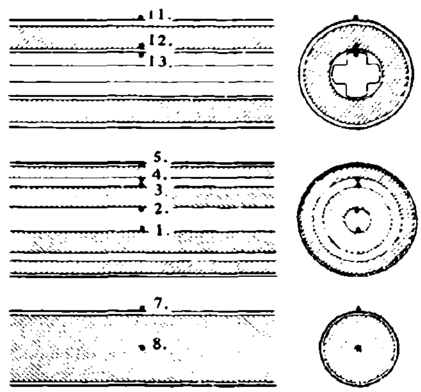


FIG. 4. Thermocouple Locations for Cold-Weather Run.

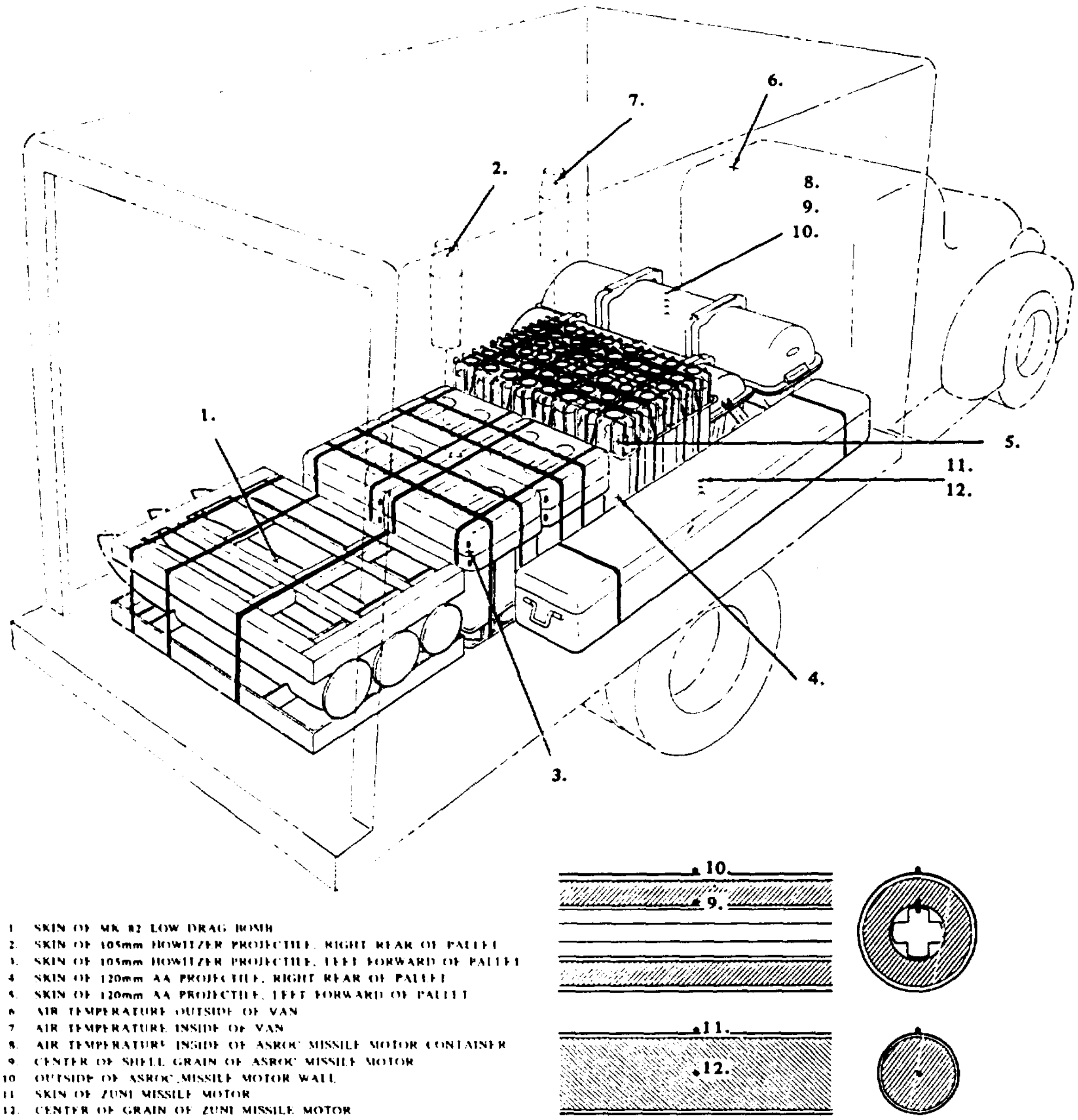


FIG. 5. Thermocouple Locations for Hot-Weather Run.

The measurement sequence for the cold-weather run was conducted over the route shown in Fig. 6. The ordnance driver and a technician started out on 30 January 1969 into a storm front that covered a large area. The route was generally north from China Lake through Oregon, Washington and northern Idaho. However, because foul weather was reported in Canada following departure, necessary arrangements were quickly made to cross the international boundary. The truck was driven through provinces of Canada, and the states of Montana, Wyoming, Colorado, Utah, Nevada, and Arizona before returning to California. Specifically the route was as follows:

US 395 from China Lake, through Oregon to Spokane, Washington

US 195 through Idaho to the US-Canadian border

British Columbia Route 93 through Kootenay National Park, Banff National Park and Jasper National Park to British Columbia Route 16

British Columbia Route 16 to Edmonton, Alberta

Alberta Route 2 to the US-Canadian border

US 89 To Great Falls, Montana

US 10 to US 283 at the edge of Yellowstone National Park (Yellowstone not entered because roads were impassable)

US 20 into Idaho

US 32 and 33 to US 26

US 26 through Grand Teton National Park to US 287

US 287 to Loveland, Colorado

US 34 and Colorado Route 7 into Rocky Mountain National Park, over Berthoud Pass to US 40

US 40 through Fraser, Colorado to Interstate 15

Interstate 15 through Utah, Arizona, and Nevada into California to US 58

US 58 and 395 to China Lake, on 13 February 1969.

Quiescent state measurements were also recorded during the cold-weather run. Periodic overnight stops permitted collection of valid data. The following overnight stops were made:

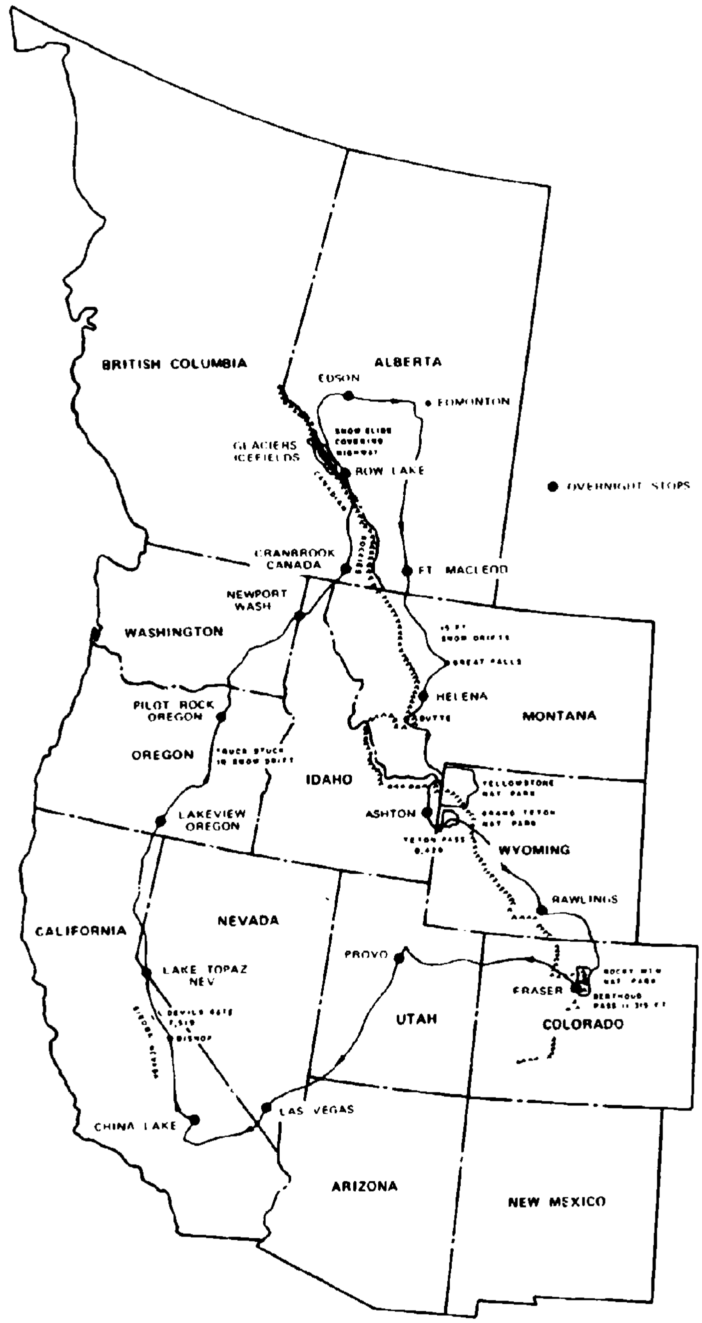


FIG. 6. Map of Cold-Weather Run.

30 January - Marleeville, at the California-Nevada border on US 395

31 January - Lakeview, Oregon, on US 395

1 February - Pilot Rock, Oregon, on US 395

2 February - Newport, at the Washington-Idaho border, on US 195

3 February - Cranbrook on Alberta Route 93

4 February - Bow Pass, (at 6,785 feet elevation) on Alberta Route 93

5 February - Edson, on Alberta Route 16

6 February - Fort Macleod, on Alberta Route 2

7 February - Helena, Montana, on US 91

8 February - Ashton, Idaho, on US 20

9 February - Rawlings, Wyoming, on US 287

10 February - Fraser, Colorado, on US 40

11 February - Provo, Utah, on US 91

12 February - Las Vegas, Nevada, on Interstate 15

This route covered some of the most rugged, severe-winter terrain to be expected anywhere in the world. Weather more severe, or roads not as well-kept, would have halted truck operation.

Hot-Weather Runs

The hot-weather, moving vehicle situation was measured during summer, 1969, using the same equipment. The basis for the measurement sequence was slightly different. NWC is located near Death Valley which holds second place for record world temperature (134°F--only 2 degrees cooler than the highest recorded in Africa). When a representative hot-spell developed, an ordnance van was dispatched from the Center through Death Valley to record the effect of moving vehicle temperatures on the ordnance.

The measurement sequence was planned for one of two predetermined routes (Fig. 7). The essential part of the route was through Death Valley, with particular interest in the area of Bad Water (282 feet below sea level).

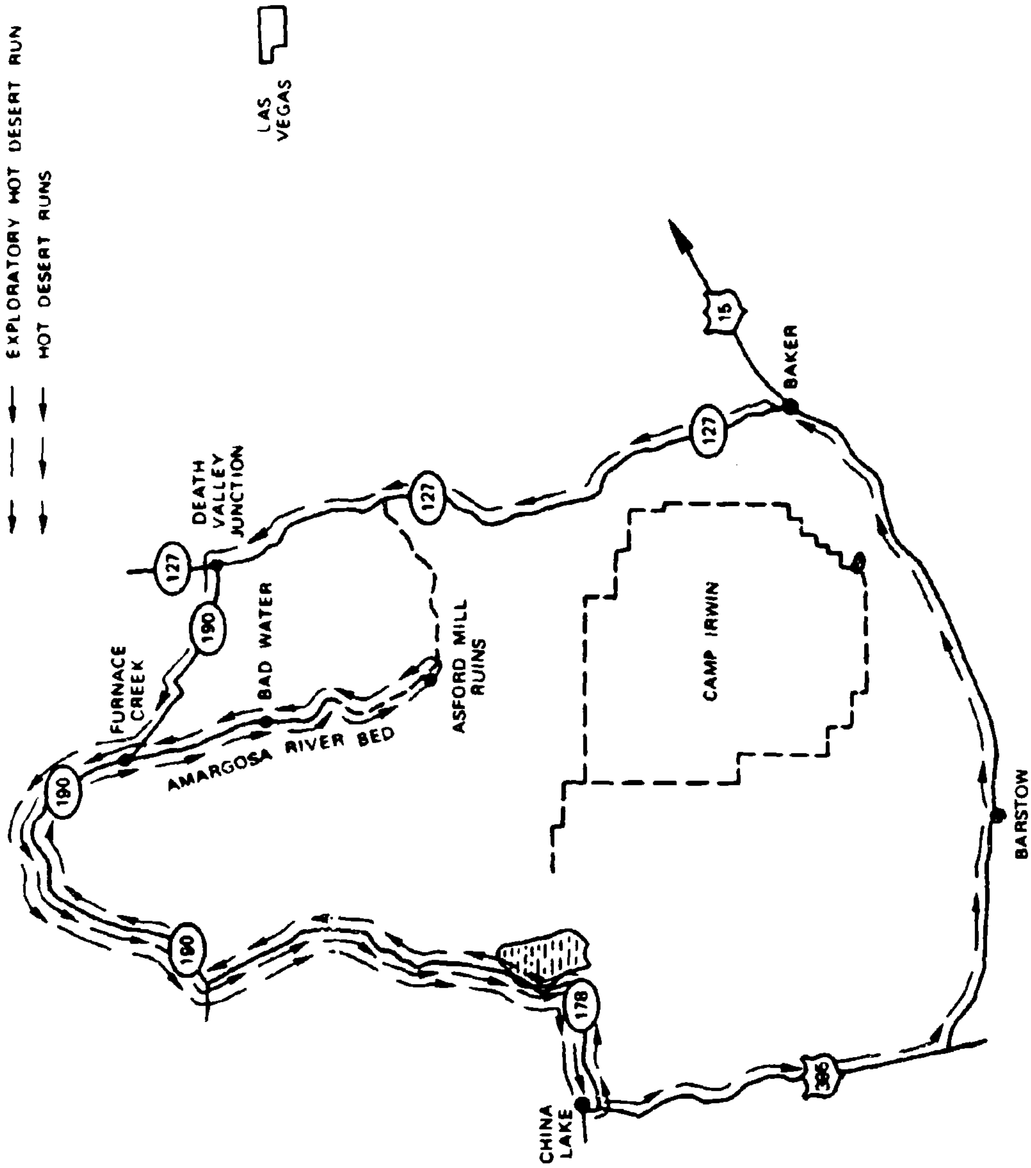


FIG. 7. Map of Hot-Weather Runs.

The first run through Death Valley was planned to (1) establish the time needed to reach the Bad Water destination, (2) sense problems needing solution before subsequent trips, and (3) determine the better route for the best measurement sequence. Both routes lay well within the boundaries of the Mohave Desert. (The U. S. Army at the Yuma Proving Ground uses the Death Valley area as its ultimate test of equipment reliability in Test and Evaluation Command (TECOM) road trials.)

A crew of driver and technician departed China Lake on 7 August 1969 for the first of five runs in this sequence. The route covered 420 miles lying completely within the State of California, south on US 395 to US 58, US 58 east to Interstate 15, Interstate 15 east to Baker, Route 127 north to Death Valley Junction, Route 190 west across the valley floor, then south on Route 178 through the Searles Valley to China Lake.

One truck breakdown and one electronic equipment failure were directly attributed to the excessive heat. The area of prime interest was not reached until late in the day because of the terrain and the distance. After the first trip and serious evaluation of the routing, the alternate route was selected for remaining runs of the measurement sequence.

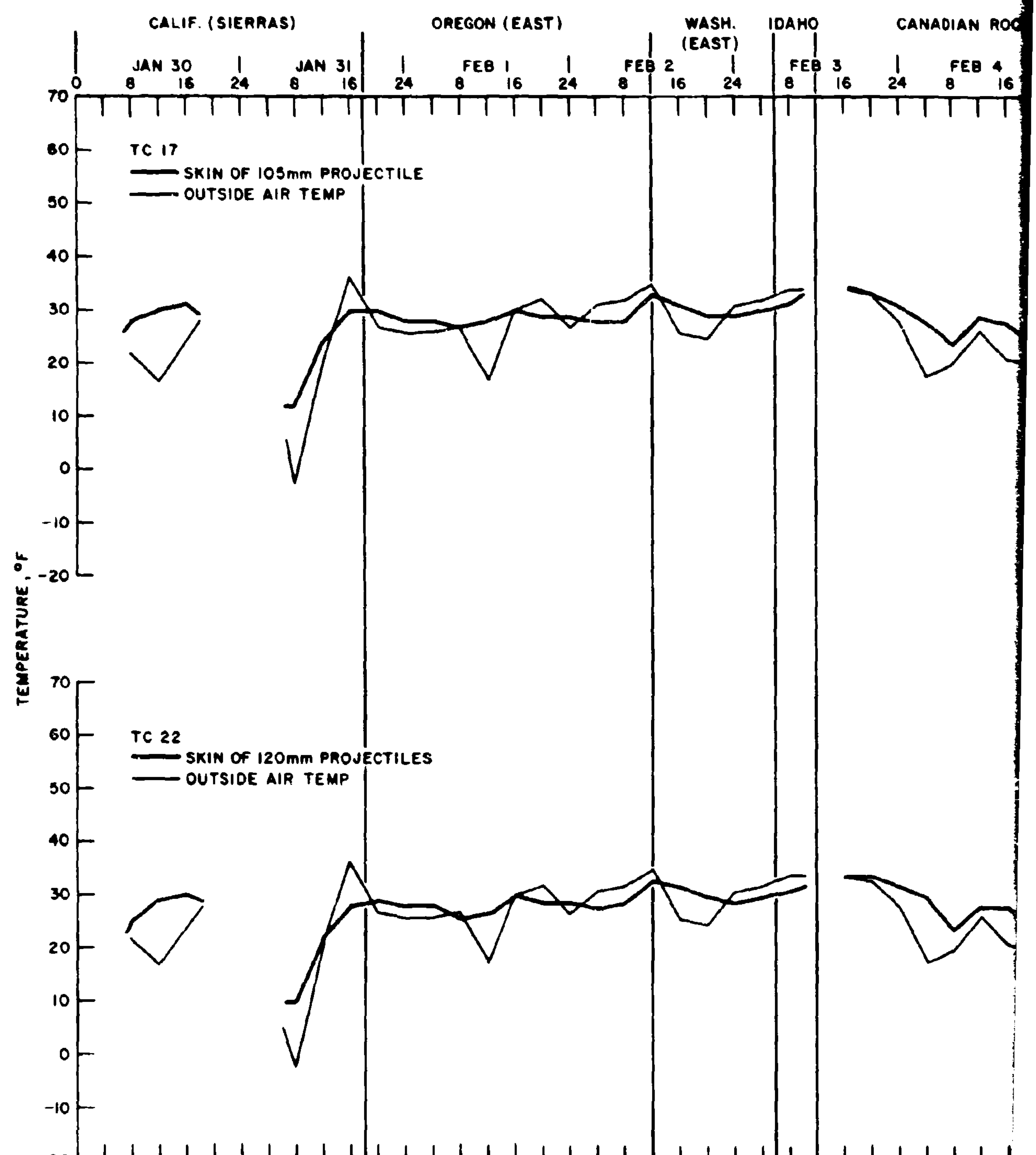
The alternate route was planned east and north on Route 178 from China Lake, through Death Valley to Furnace Creek and Bad Water. Turning south, the planned route followed the Amargosa Dry River bed to the southern tip of Death Valley, 45 miles below Furnace Creek. From this point, the route was retraced to China Lake. The planned route proved to be valuable for collection of extreme data, but extremely grueling on men and equipment. On the last day of the hot-weather runs, there were numerous breakdowns of the truck and a second failure of the inverter. While repair crews were on hand each night to repair and check out equipment for the next daily run, it seems obvious that equipment was being operated beyond limitation.

The single exception to normal loading and hauling specifications was the installation of refrigeration air conditioning in the cab of the truck for hot-weather runs. The Death Valley National Park Rangers were notified of impending runs because of the severely hot conditions in Death Valley during the summer and the near-total absence of highway traffic, especially in the area of Bad Water. The Rangers gave full cooperation, requesting only that they be notified on arrival and departure each day.

RESULTS

COLD-WEATHER RUN

A trip log for the cold-weather run is presented in Appendix A. The measured data are presented in Fig. 8 through 10, and Table 2 of Appendix B.



CALIF. (SIERRAS)
OREGON (EAST)
WASH. (EAST)
IDAHO
CANADIAN RO
JAN 30
JAN 31
FEB 1
FEB 2
FEB 3
FEB 4
TC 17
SKIN OF 105mm PROJECTILE
OUTSIDE AIR TEMP
TEMPERATURE, °F
TC 22
SKIN OF 120mm PROJECTILES
OUTSIDE AIR TEMP

FIG. 8. Co

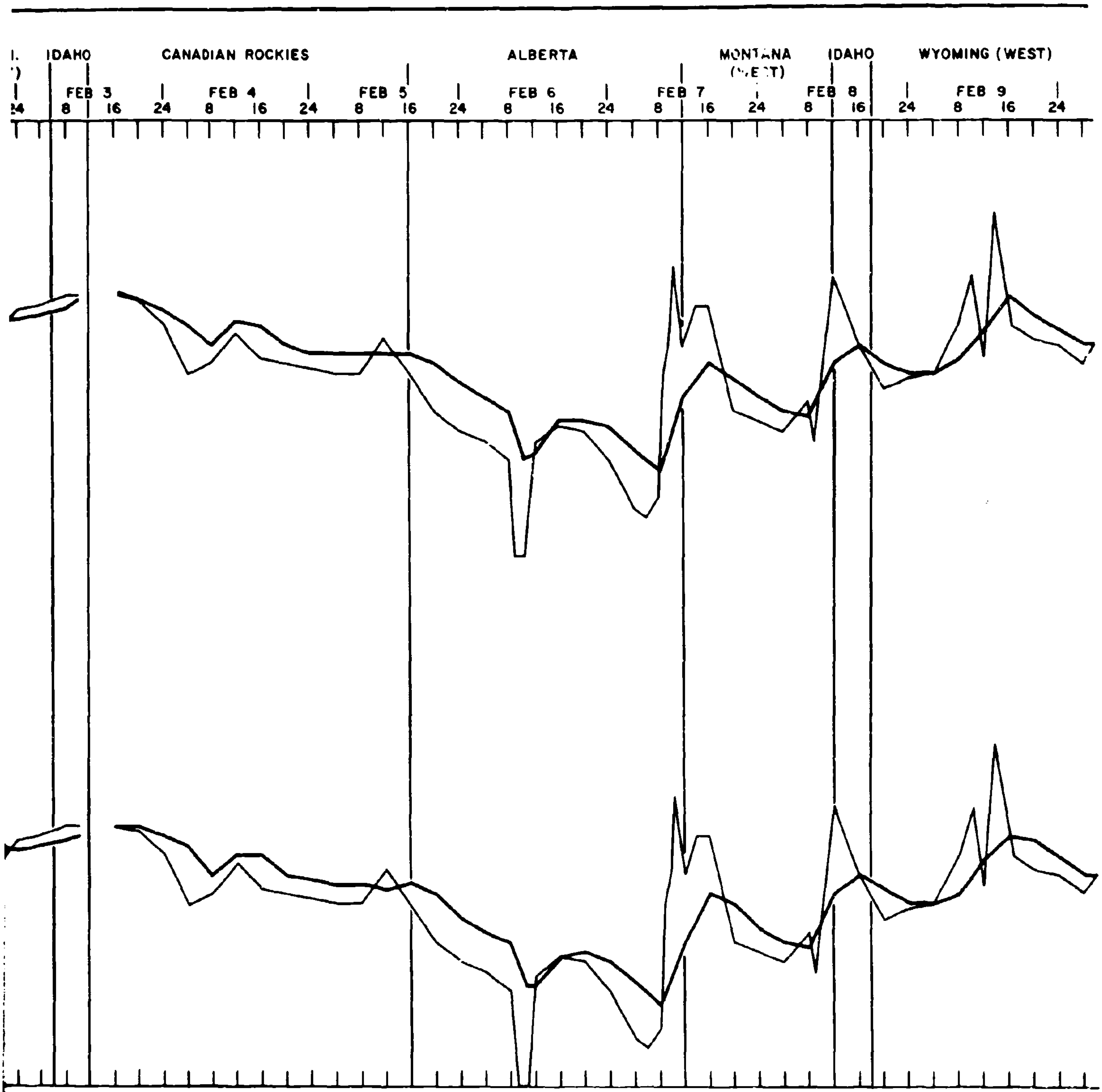
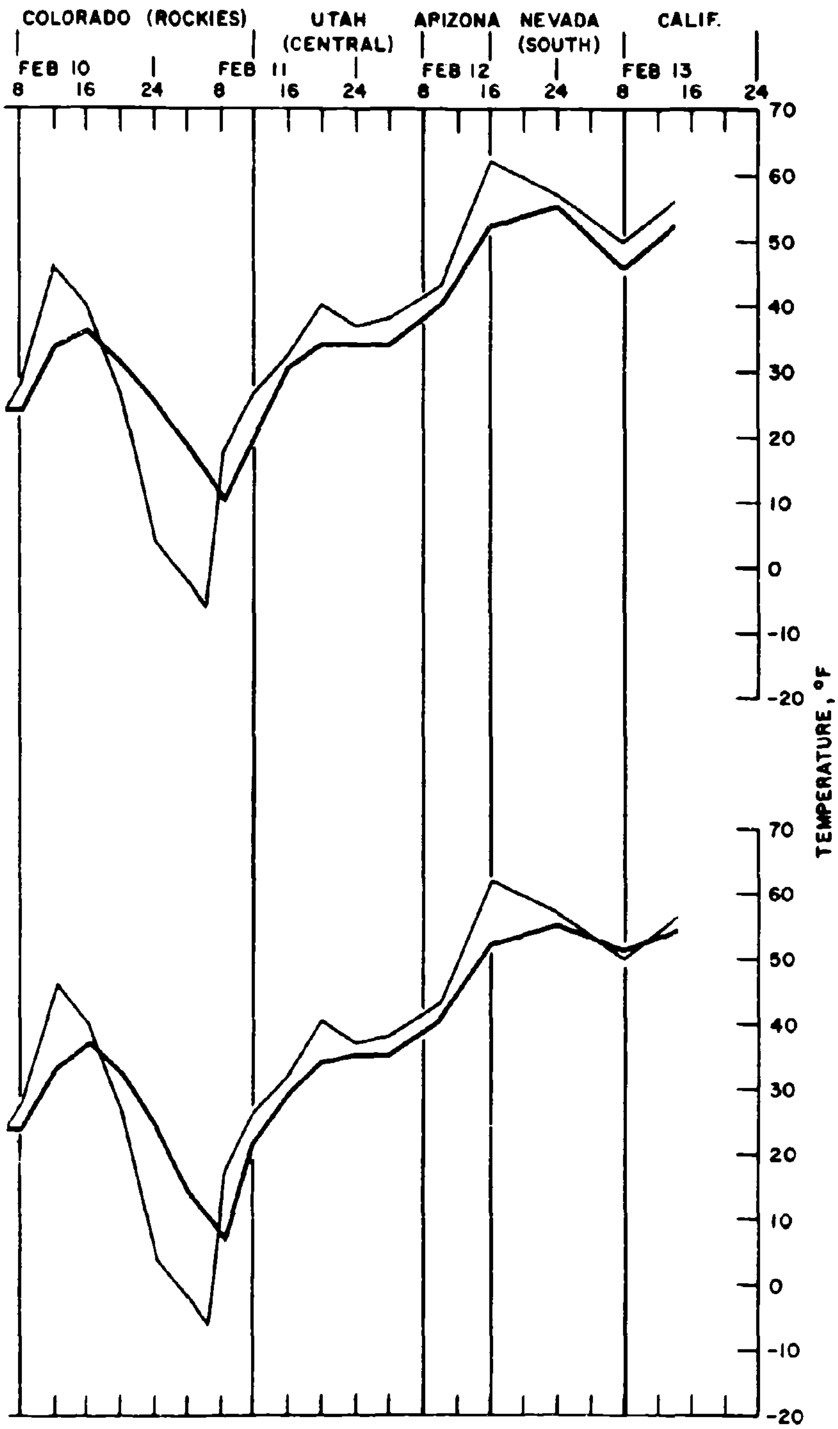
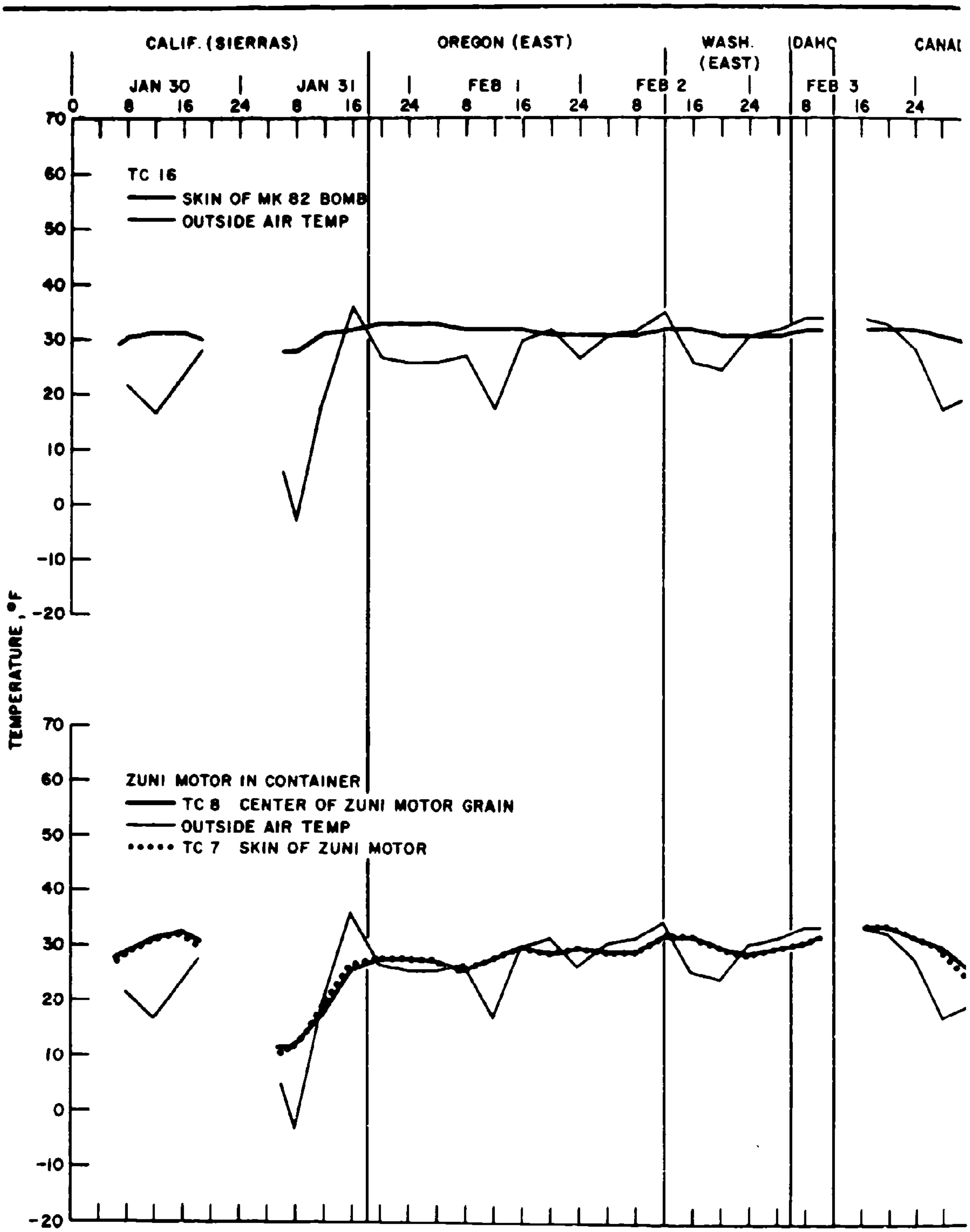
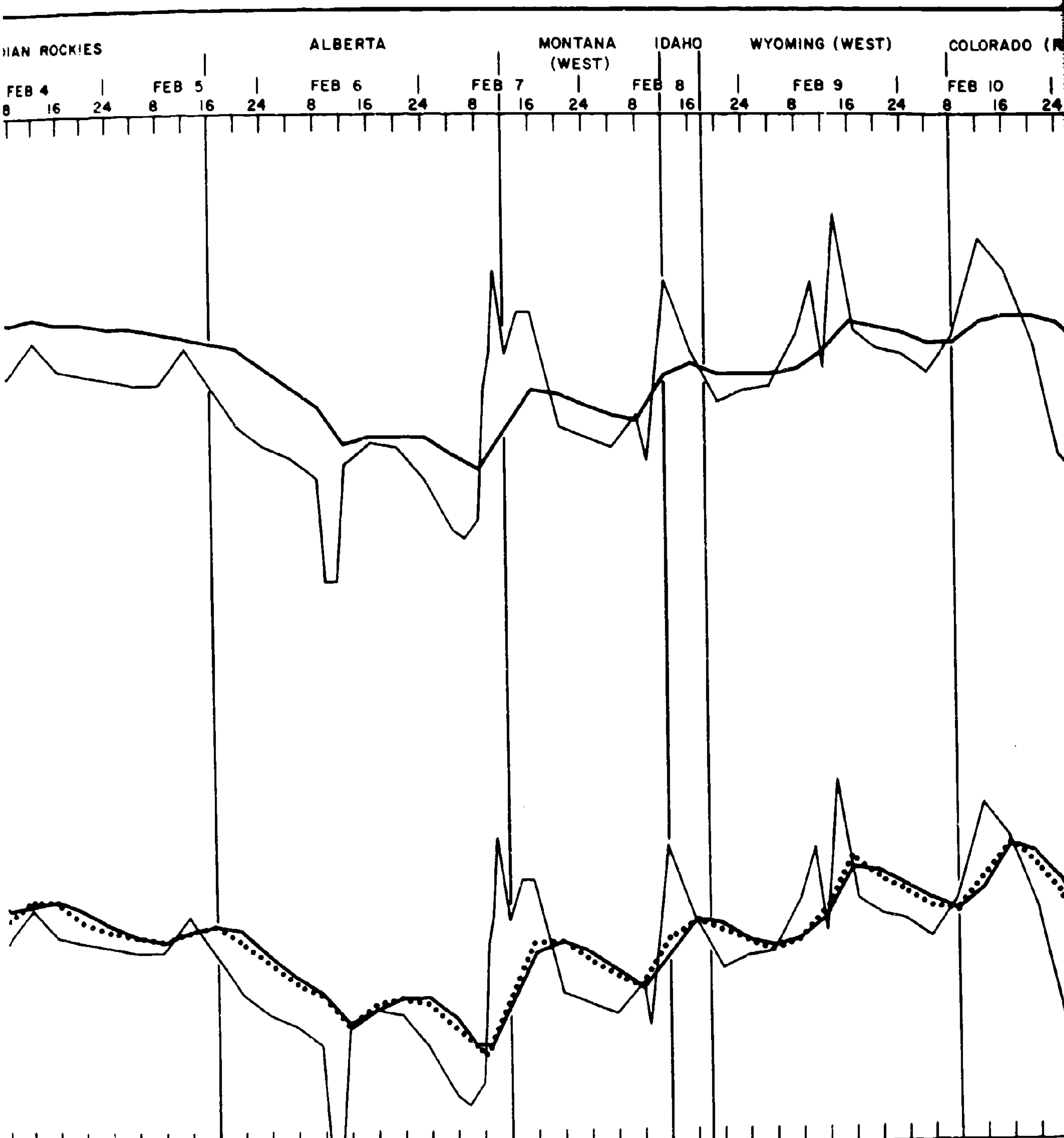


FIG. 8. Cold-Weather Run Temperature Profiles - 105 and 120mm Projectiles.

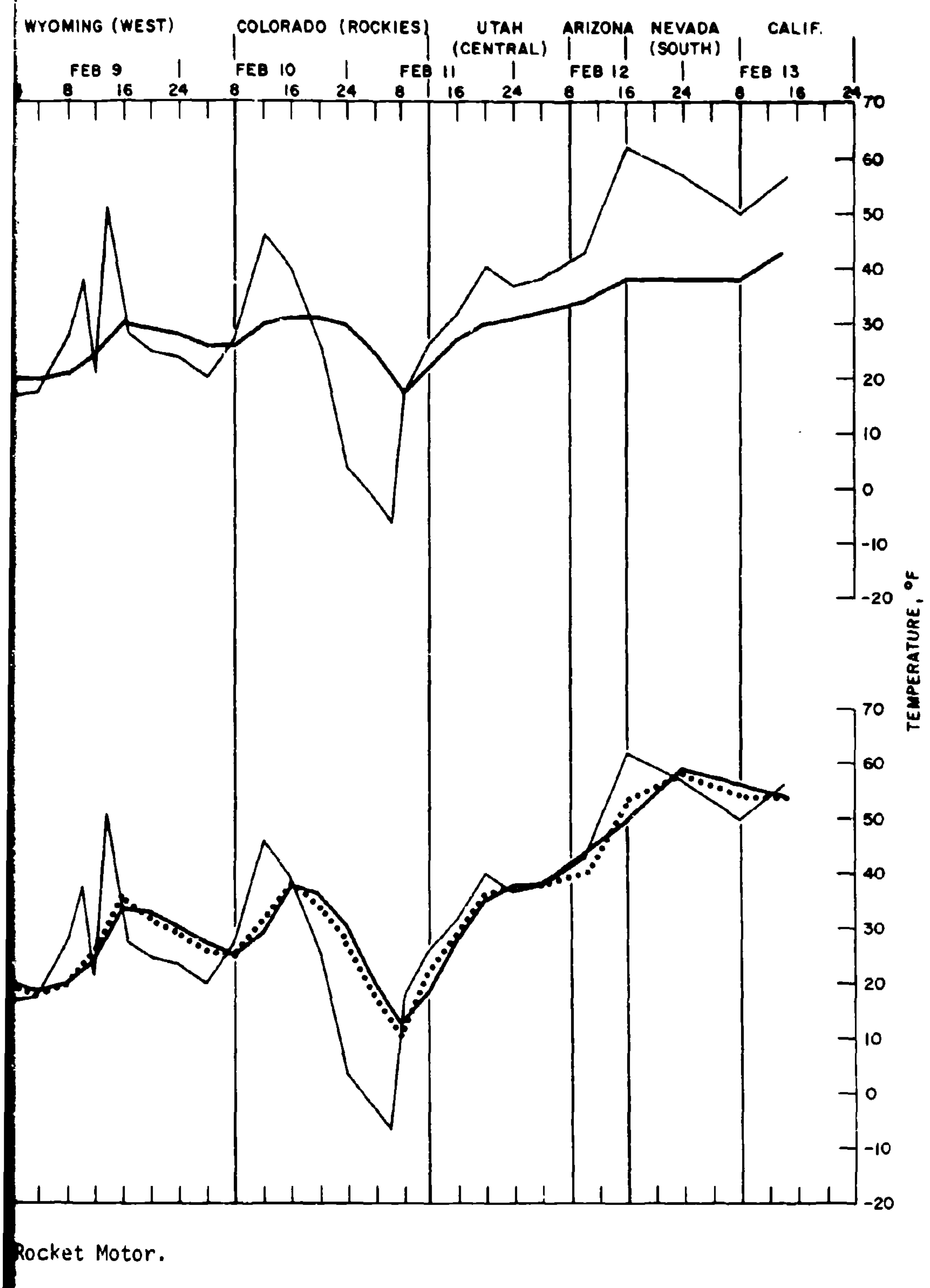

COLORADO (ROCKIES)
UTAH (CENTRAL)
ARIZONA
NEVADA (SOUTH)
CALIF.
FEB 10
FEB 11
FEB 12
FEB 13
8 16 24 8 16 24 8 16 24 8 16 24
70 60 50 40 30 20 10 0 -10 -20
TEMPERATURE, °F
70 60 50 40 30 20 10 0 -10 -20


CALIF. (SIERRAS)
OREGON (EAST)
WASH. (EAST)
IDAHO
CANA
JAN 30
JAN 31
FEB 1
FEB 2
FEB 3
0 8 16 24 8 16 24 8 16 24 8 16 24 8 16 24
70 60 50 40 30 20 10 0 -10 -20
TEMPERATURE, °F
TC 16
SKIN OF MK 82 BOMB
OUTSIDE AIR TEMP
ZUNI MOTOR IN CONTAINER
TC 8 CENTER OF ZUNI MOTOR GRAIN
OUTSIDE AIR TEMP
TC 7 SKIN OF ZUNI MOTOR

FI



G. 9. Cold-Weather Run Temperature Profiles - Mk 82 Bomb and Zuni Rocket Motor.



Rocket Motor.

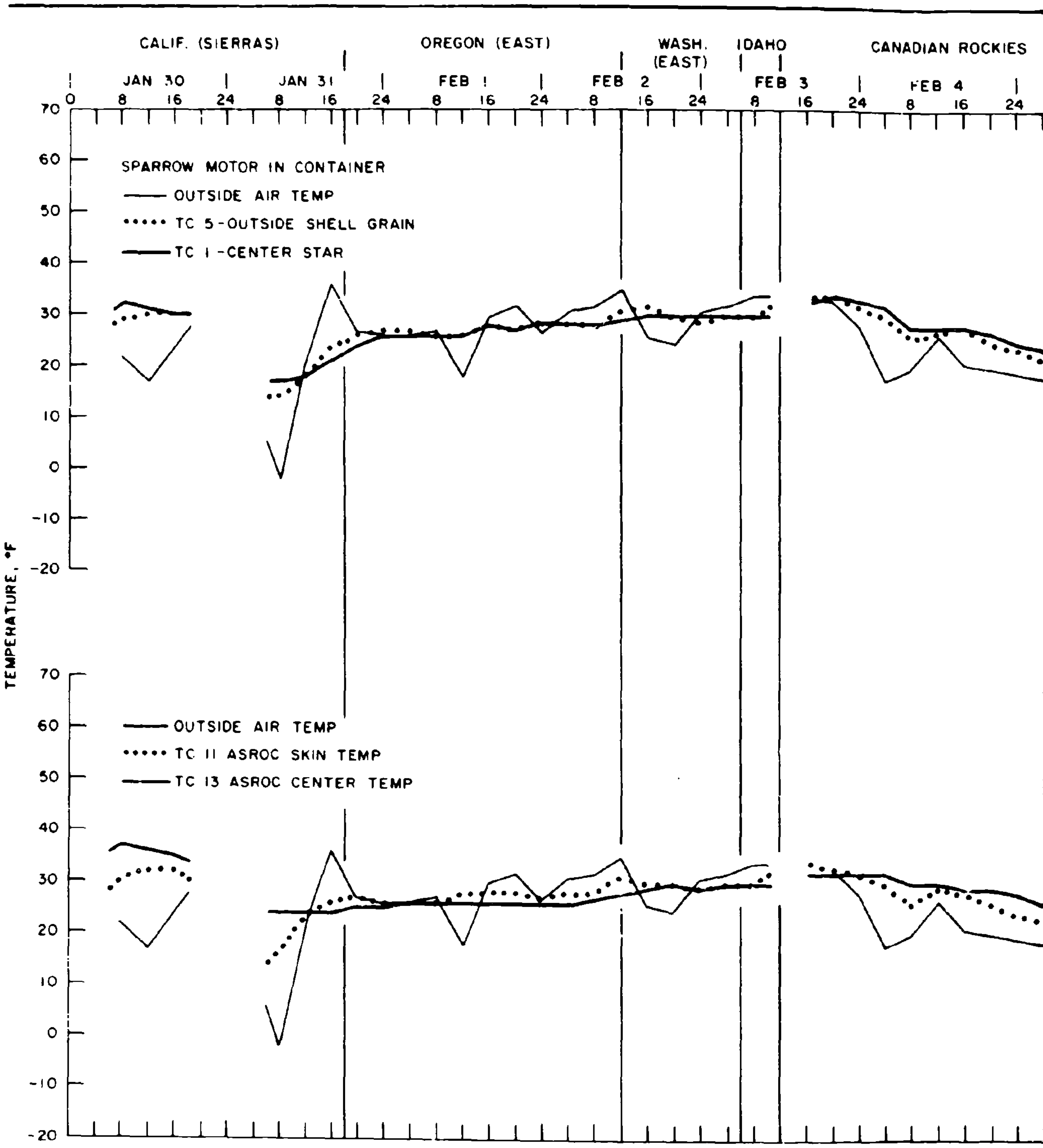


FIG. 10. Cold-Weather

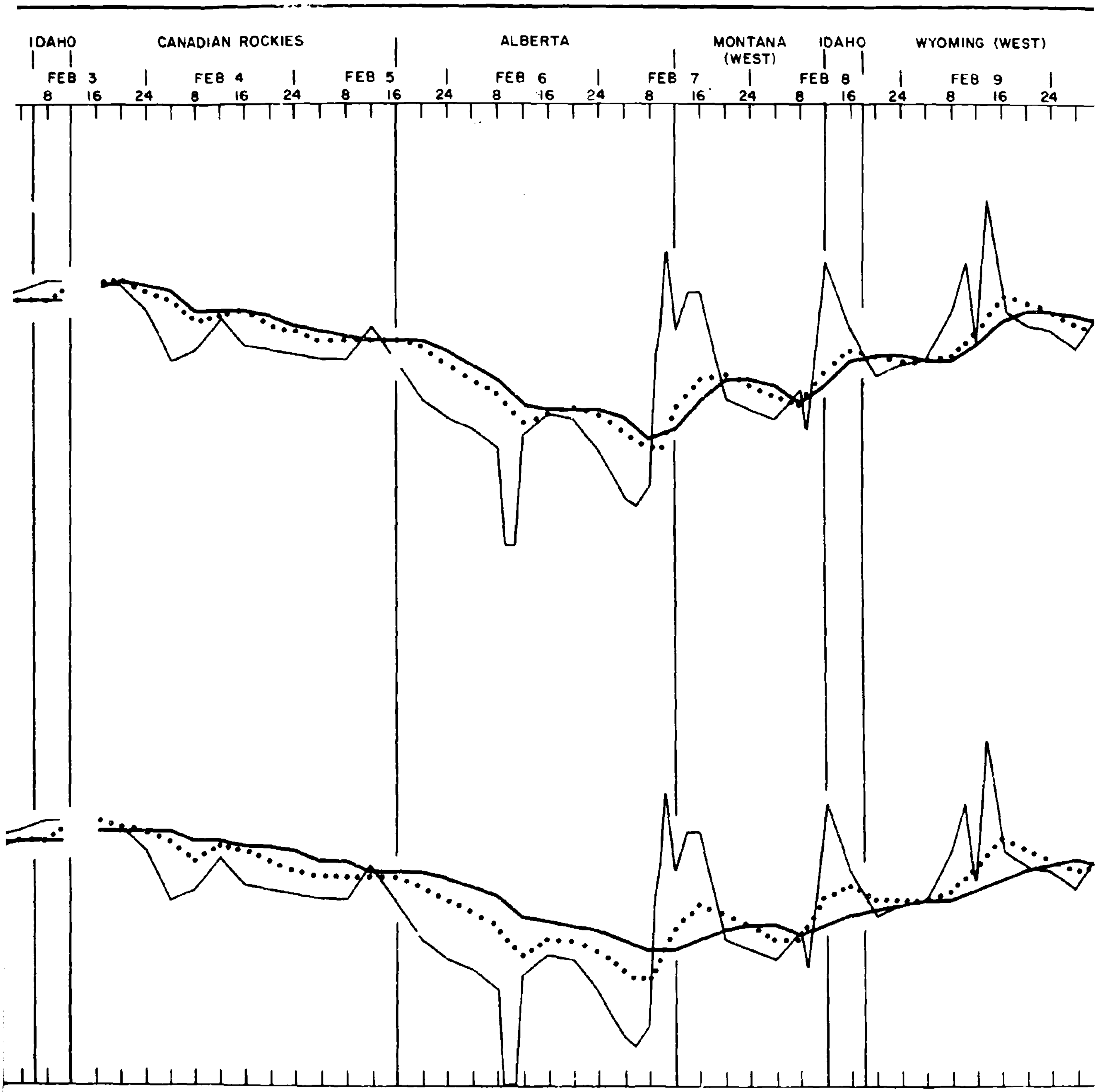
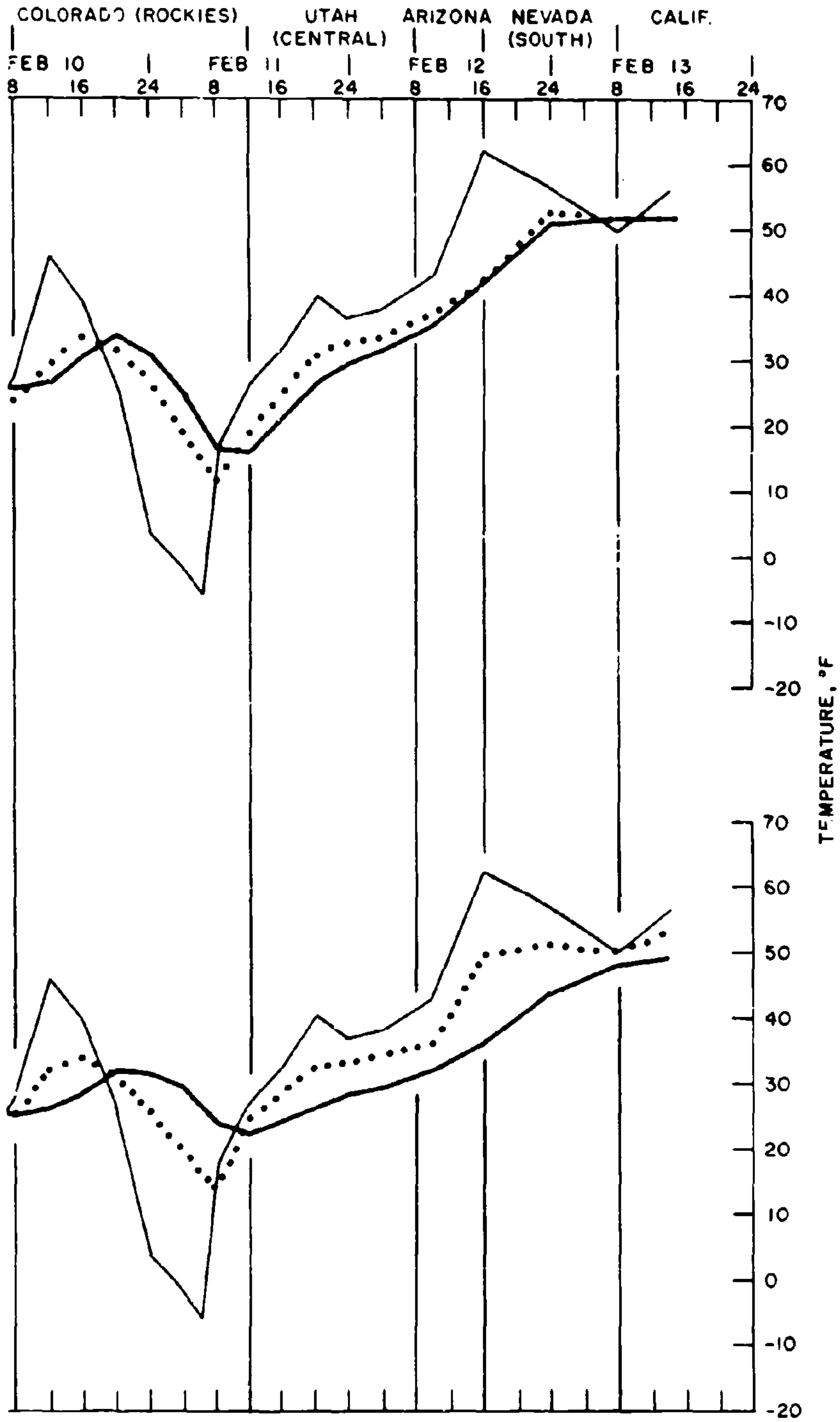


FIG. 10. Cold-Weather Run Temperature Profiles - Sparrow and ASROC Rocket Motors.


COLORADO (ROCKIES)
UTAH (CENTRAL)
ARIZONA
NEVADA (SOUTH)
CALIF.
FEB 10
FEB 11
FEB 12
FEB 13
8
16
24
70
60
50
40
30
20
10
0
-10
-20
TEMPERATURE, °F

Data from the cold-weather, moving-vehicle run are complete in that continuous information is recorded for each ordnance item from departure at China Lake until return 15 days later. Only two short interruptions in the data developed--power interruption (30-31 January, 1930-0600 and 3 February, 1100-1700).

Ordnance items were chosen for this investigation by volume and weight characteristics rather than by type of weapon.

An interesting correlation exists between the size of ordnance and thermal lag, the thermal lag being a direct function of ordnance mass. Considerable difference can be noted between outside air temperature and that measured inside ordnance items (Fig. 8 through 10). The van offers considerable protection to ordnance during transport. The heat generated by moving parts of the truck, nd the conduction of heat from one component to another can be factors affecting lag time. The engine, transmission, wheels, axles, and even the heater in the cab may be minor sources of heat which could affect the ordnance.

The temperature profile for truck-transported ordnance is also affected by the changing environment of the moving truck. Driving in the mountains can be actually warmer than driving in a flat, open area. This condition developed as the crew and truck moved from the Canadian Rockies onto the flat plain near Edmonton, Alberta. Nearly all temperature extremes were recorded as the van passed through particularly cold or warm areas. Temperatures during quiescent periods (1800-0600) were fairly stable, especially during a heavy snowfall.

The meteorological data for the days encompassing the cold-weather run are given in Appendix C.

What effect do these factors have on a piece of ordnance? Most conditions dampen the response of ordnance to temperature extremes: note how the outside air temperature profile crosses that of an ordnance item. Highs and lows of air temperature form an envelope, within which lie high and low ordnance temperatures. One could say that overall ordnance temperature is almost an average of overall extremes of air temperature.

HOT-WEATHER RUNS

A trip log for the hot-weather runs is given in Appendix A. Results obtained from the hot-weather runs are given in Fig. 11 through 15, and Tables 3 through 7 of Appendix B. Even though a standard ordnance van was used, the measurement sequence was too severe for the machine. Events during the runs illustrate a history of malfunctioning equipment when continuously operated in the intense and continuous heat.

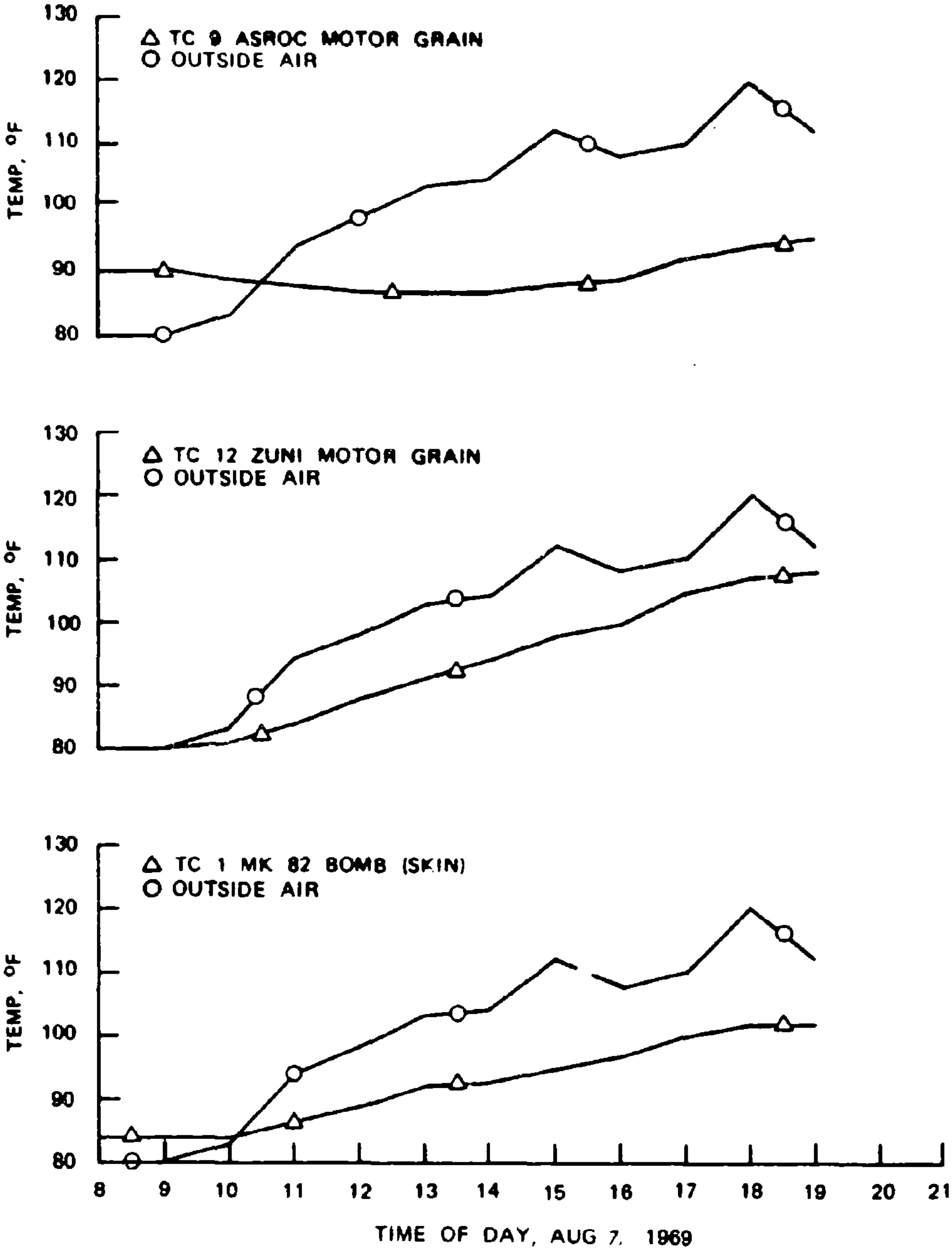


FIG. 11. First Day Hot-Weather Run.

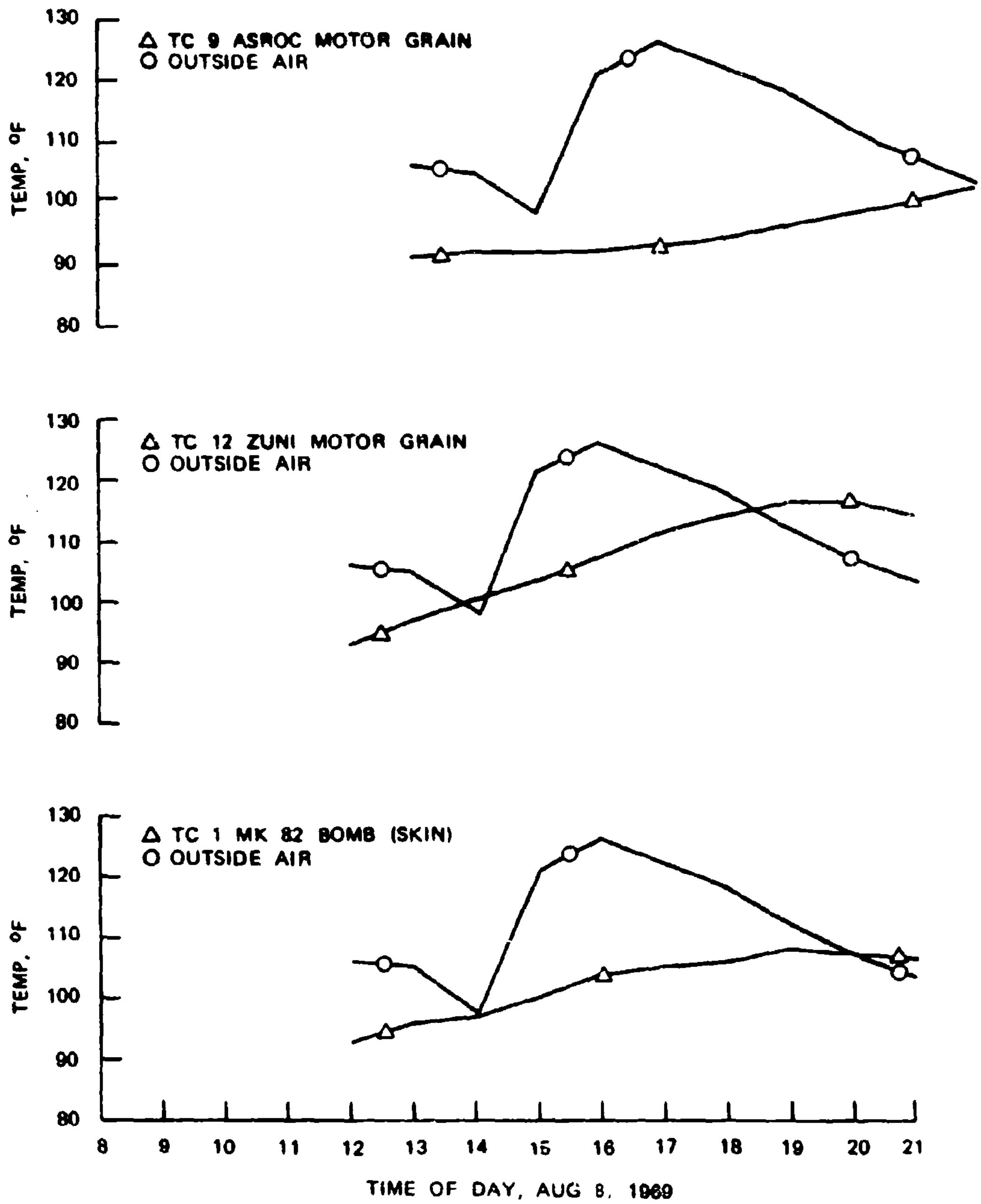


FIG. 12. Second Day Hot-Weather Run.

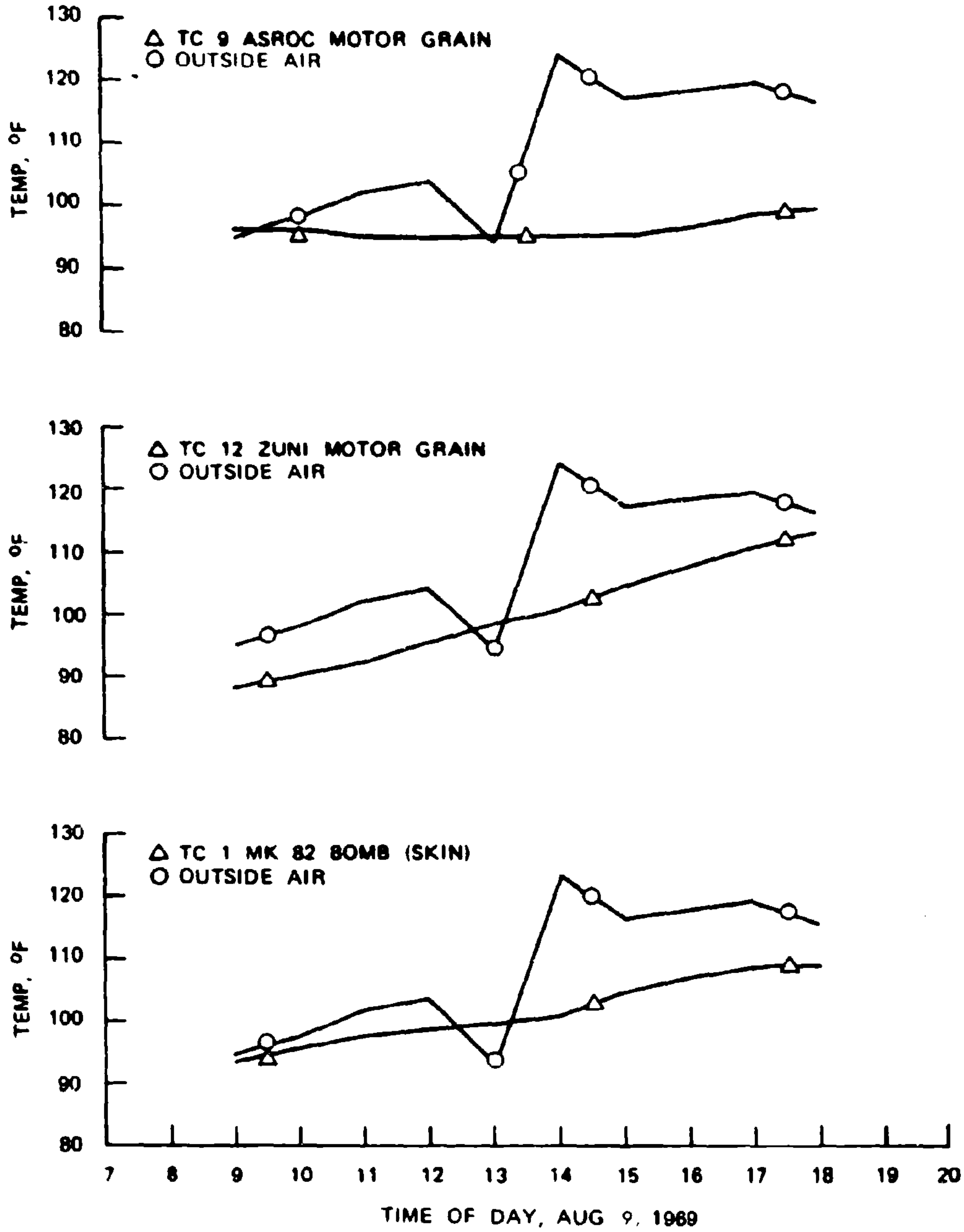


FIG. 13. Third Day Hot-Weather Run.

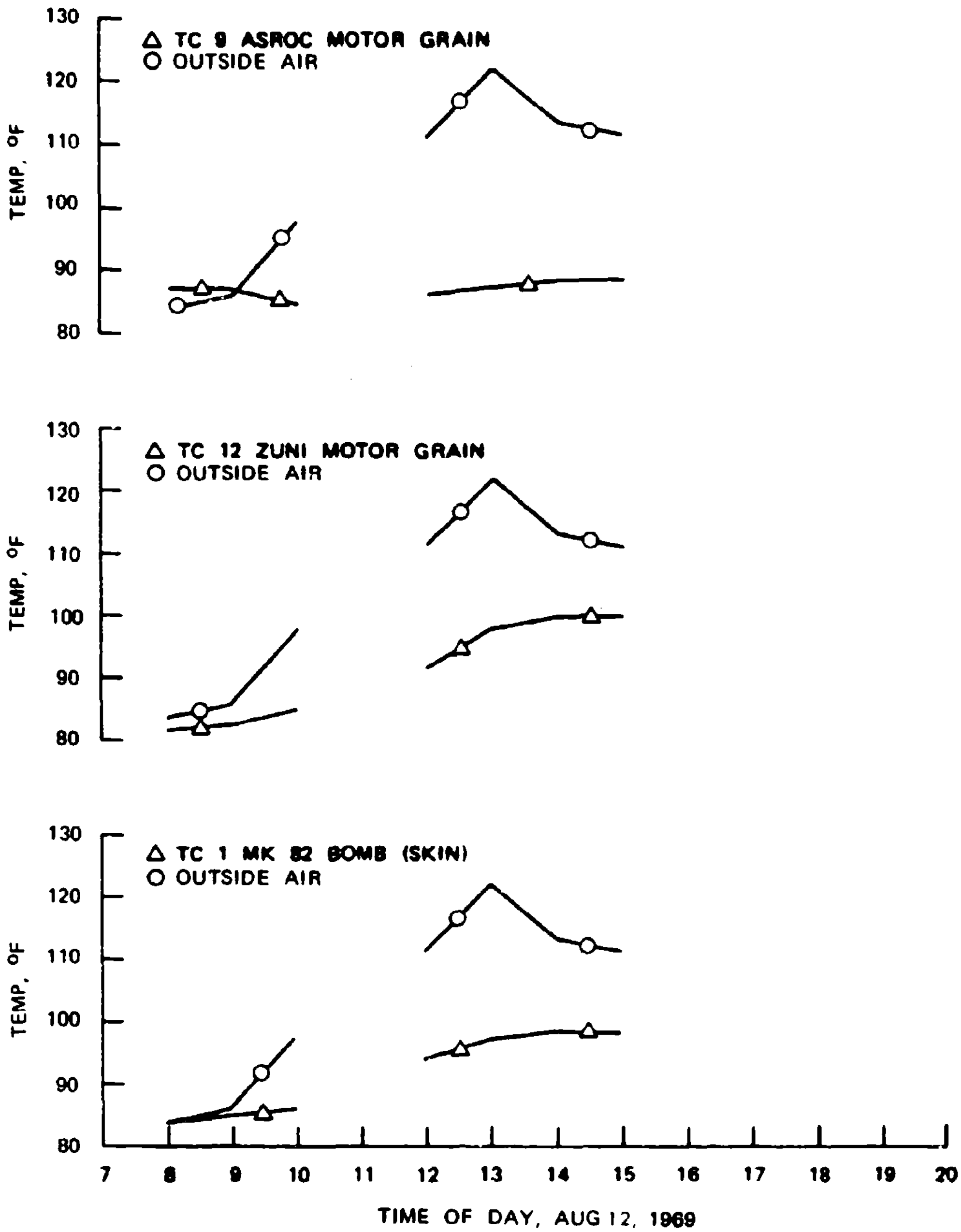


FIG. 14. Fourth Day Hot-Weather Run.

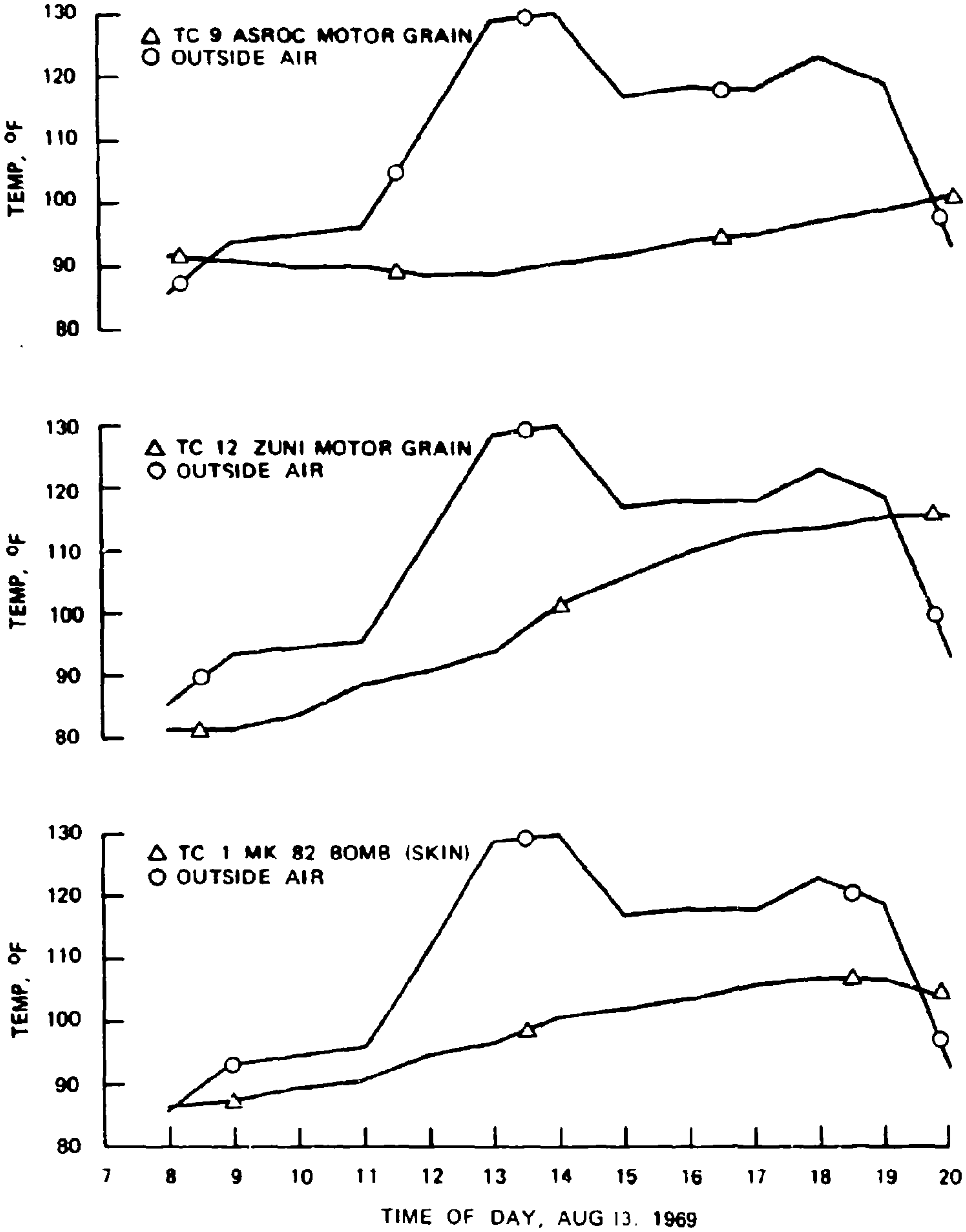


FIG. 15. Fifth Day Hot-Weather Run.

Comparison of data obtained in the measurement sequence of 7-13 August 1969 indicates that thermal lag due to ordnance mass is appreciable. Outside air temperatures peak between 120 and 130°F and all ordnance temperatures lie between the maximum and minimum values on these response curves (Fig. 11 through 15). It is evident that each ordnance unit has a unique thermal time constant, and consequently, a different lag characteristic. However, comparison of onset temperatures of the ordnance and of outside air indicates larger units are less active thermally. For example, the larger ASROC missile motor exhibits a higher nighttime temperature, but does not seem to respond to thermal driving force (van air temperature) as rapidly as does the Zuni missile motor. Zuni temperature appears to reach equilibrium with van air temperature at night.

The peculiarities of thermal lag can be observed in the complete set of data in Tables 3 through 7 of Appendix B. An extra variable is presented by the truck in movement; therefore, outside air temperature is not a constant, predictably changing variable.

ANALYSIS

To obtain a fairly accurate insight into the probabilities of occurrence of high, or low temperatures to be experienced by truck transported ordnance, it is necessary to idealize the many parameters. This has been attempted by the authors in analyzing the truck situation. Briefly, the results of the analysis are as follows:

1. If the extreme situation is to be measured, the truck must be spotted permanently in the area of interest. Appendix D (Fig. 22, 23, and 24) contains a sample of data from three areas of interest where trucks are presently spotted. Even though these figures give only data samples that are by no means conclusive, they do give an indication of temperature profiles. A comparison of Fig. 8 and 23 shows that while the truck was moving through the Bridgeport area on 30 January a minimum ordnance temperature of 23°F was measured, whereas a minimum ordnance temperature of 20°F was measured in the truck spotted at the Bridgeport measurement site. A comparison of the temperature measurements on a Zuni motor (Fig. 12 and 22) on 8 August shows that while the truck was moving through the Death Valley area, an ambient air temperature of 128°F and an ordnance temperature of 116°F was recorded; at the NWC measurement site, where temperature conditions very similar to Death Valley are experienced, an ambient air temperature of 112°F and an ordnance temperature of 111°F was measured. This indicates a much higher temperature differential between ordnance and ambient air temperatures under moving-vehicle conditions.

2. During hot weather, if the truck is moving, it is cooled by its passage through air. The difference between radiation induced temperature change and convection induced temperature change is considerable.

3. In cold weather, heat from the truck tends to modify the lower temperature extremes.

4. The change in meteorology with change of road elevation and surrounding terrain for a moving truck complicates the correlation of data between measured ordnance responses and measured meteorology.

Since some of the above problems were anticipated previous to this measurement series, measurement sites have been established in five different climates: hot desert, cold sierra, marine influenced arctic, inland arctic, and tropical. The plan is to leave van trucks, loaded with ordnance, spotted at these sites until sufficient statistical information is obtained. In this way, the statistical implications for a given thermal profile can be evaluated. Although the data presented in Appendix D are limited, they are included in this report because they do not exist in print elsewhere.

CONCLUSIONS

This measurement series has shown that no piece of ordnance will be subjected to the extreme temperatures of the surrounding environment while being transported by truck. During the cold-weather run, the lowest outside air temperature measured was -20°F; however, the lowest ordnance temperature measured was -3°F. During the hot-weather runs, the highest outside air temperature measured was 128°F; however, the highest ordnance temperature measured was 116°F.

An analysis of the data obtained from the measurement series indicates the following:

1. The quiescent state seems to be most conducive to temperature extremes.

2. Truck transported ordnance is cooled in hot weather by convection.

3. Meteorological conditions any more severe than those reported would seriously impair the military effectiveness of equipment.

4. The temperature profiles presented are considered typical of extreme truck transport conditions.

Appendix A

TRIP LOG

COLD-WEATHER RUN

A summary of trip conditions during the cold-weather run is given in Table 1.

The first day out, 30 January 1969, was clear, but only 264 miles were covered due to the mountainous country. The first storm front was not reached until the following day. During the night of 30-31 January, power for the 110 VAC extension to the recording system was inadvertently cut off. This accounts for the loss of data during this period.

Note a -2°F temperature recorded on January 31 (Appendix B). It was recorded while traveling down a long valley (5,800 feet elevation) surrounded by mountains. This sharp reduction of valley temperature in contrast to high mountain temperature graphically shows that the cold air is locked in the valley by the mountains. Snow started to fall shortly after, reducing visibility to 100 yards or less. During the stop at night, the truck was covered with 8 inches of snow. The snow created poor driving conditions on 1 February. Visibility remained at 100 yards or less, with snow at a depth of 3 to 5 feet.

Traveling in northern Oregon on 2 February, the wind rose to 30 knots, creating poor visibility from the blizzard-like conditions. Drifting snow covered the highway. At this point, the truck bogged down, and the crew had to sit for 2 hours before being towed free.

The next day (3 February) brought little relief. It snowed heavily; the snow level varied from 5 to 8 feet, with drifts 10 feet deep. The crew followed snowplows all of this day, for very slow going. Only 152 miles were covered in 9 hours of driving. The rhythmic bouncing of snowplows chopped chunks of ice from the surface, about 4 feet apart and from 3 to 5 inches deep. The ordnance van bounced along under such conditions for approximately 100 miles. At one time, bouncing was so severe that a pallet of three 500-pound bombs jumped 2 feet off the van floor, and broke a hole in the inside rear door panel. The bouncing also caused a malfunction of the recorder and consequent loss of data during this period. Ingenuity of the crew permitted quick repair of the damage. The United States-Canadian border was reached this day, where local reports established that a severe storm was over the Canadian Rockies. After making necessary arrangements with officials at Vancover, British Columbia, the truck and crew were permitted to cross into Canada.

TABLE 1. Trip Conditions During Cold-Weather Run.

Date	Start[a] time	Road[b] conditions	Driving[c] time, hr	Hours[d] stopped	Maximum air temp., °F	Minimum air temp., °F	Weather conditions	Miles traveled
1-30-69	0710	Fair	9	15	28	17	Clear	264
1-31-69	0755	Fair	9	15	40	-2	Snowing	338
2-1-69	0700	Poor	11	13	32	18	Snowing	339
2-2-69	0800	Poor & hazardous	8	16	38	24	Snowing, drifts on highway (truck stuck 2 hours in drift)	280
2-3-69	0715	Poor	9	15	36	28	Snowing hard, followed snowplows, road very rough	152
2-4-69	0720	Extremely poor & hazardous	8	16	33	17	Snowing very hard, visibility near zero, followed snowplows	255
2-5-69	0825	Extremely poor & hazardous	7	17	25	5	Snowing very hard, poor visibility, avalanche covered highway, snowplows not able to keep highway clear	233
2-6-69	0620	Extremely poor & hazardous	12	12	8	-20	Ice fog, everything covered with ice	437
2-7-69	0700	Extremely poor & hazardous	11	13	40	-12	Blowing snow, poor visibility, wind velocity about 50 knots	341
2-8-69	0700	Extremely poor & hazardous	9	15	38	4	Snowing hard, drifting snow	280
2-9-69	0720	Poor & hazardous	11	13	51	14	Clear, roads iced over	375
2-10-69	0700	Good	10	14	45	4	Clear	350
2-11-69	0630	Good	12	12	49	-6	Clear	430
2-12-69	0645	Good	10	14	62	37	Clear	407
2-13-69	0700	Good	7	End of run	56	50	Clear	201

[a] Departure time of truck each morning.

[b] Good - very little to no ice on highway, traffic moving normal.
Fair - ice on highway, traffic moving well.
Poor - ice and snow on highway, traffic moving slowly.
Poor & hazardous - ice and snow on highway with poor visibility due to falling or blowing snow.
Extremely poor & hazardous - very poor visibility, snowplow not able to keep roads clear, traffic almost at a standstill.

[c] Actual hours truck was moving.

[d] Includes total time truck stopped (meals, coffee, and rest).

On 4 February, the ordnance van started into the Canadian Rockies. This was the first year that the Canadian Highway Department attempted to keep this highway into the Rocky Mountains clear. Visibility was near-zero at times, with the snow level between 4 and 9 feet. The crew traveled behind snowplows most of the day, and spent the night in a mountain lodge near Bow Lake. It snowed heavily during the night.

On the morning of 5 Feburary, the truck was almost completely covered with snow. The crew had to wait for snowplows to clear the way before they were able to move out. The elevation at this point was 7,000 feet. An avalanche covered the highway--the road was closed until this was cleared. Visibility was near-zero, under "white-out" conditions. There were more delays during the day's run, waiting for plows to clear away snow. Ice, which had been building on the back of the van since 31 January, was found to be 8-inches thick on 5 February.

The crew was out of the Rockies and heading over very flat land toward Edmonton, Alberta, on 6 February. The snow had stopped falling, but the temperature began to drop. At 2,500 feet elevation, -20°F was recorded. During this very cold interval, the crew ran into ice-fog. Visibility was very poor. Ice formed on all of the ordnance inside the van, a condition that lasted for about 4 hours.

The morning of 7 February offered little relief from the cold. Excepting a short interval on 6 February, the temperature remained below zero for 26 hours. The crew at this time was traveling over flat land, about 75 miles east of the Canadian Rockies (south on Alberta Route 2). During the day, the wind velocities rose to 50 knots and snow drifted 15 feet deep. Blowing snow reduced visibility to nearly zero. The following day, 8 February, while traveling along open Montana ranges, the crew again encountered drifting snow and high winds. When they reached Yellowstone National Park, the snow level was 6 to 10 feet. Teton Pass, at 8,400 feet elevation, was crossed on 9 February. It had been closed the previous day due to heavy snow.

On 10 February, the crew traveled south along the eastern edge of Rocky Mountain National Park. They went over Berthoud Pass (11,300 feet) and spent the night in Fraser, Colorado. Fraser, lying in a sump in the valley floor and surrounded by mountains, was noted to be 10 degrees colder than any place within 5 miles. The remainder of the trip to China Lake was without incident.

HOT-WEATHER RUNS

First day (7 August) - loss of fan belt and all air conditioning for the driver and technician. The men consumed, without discomfort, 10 gallons of liquid which was apparently dissipated as perspiration.

The inverter overheated late in the run, on the return to China Lake. However, this occurred in the Panamint Valley and the Death Valley data were not jeopardized by this loss of power.

Second day (8 August) - following all night maintenance and inspection of the truck and equipment, the second run was attempted. This run went smoothly until leaving Death Valley on the return trip, when the air conditioning belts again failed. Another night of maintenance and repair was required.

Third day (9 August) - the third run was attempted, but the run ended in equipment breakdown. As the van entered Death Valley, the vibration dampener dropped off. This unit runs all auxiliary power units, such as the alternator, the coolant pump, and cab air conditioning. After reaching one of the few telephones in Death Valley, the crew was instructed to keep inverter and recorder running until the battery failed. Data for 9 August indicate that the battery lasted until just after 1900 hours. A standard heavy-duty wrecker, modified for hot-weather use, was dispatched from China Lake to retrieve the ordnance van. Heat forced a number of stops in the Death Valley region. On return to NWC at 0130 on 10 August, the van was again subjected to repair and inspection. Necessary parts to replace a failing clutch were not on hand. This caused a 2-day break in the temperature measurement sequence.

Fourth day (12 August) - the fourth run of the measurement sequence started well, and lasted for about 2 hours. Then the alternator, voltage regulator, and battery went up in smoke. Using spare, heavy-duty batteries delivered by truck from China Lake, the run was completed on battery power, without benefit of cab air conditioning. Another all-night repair cycle was required.

Fifth day (13 August) - the fifth (and last) run was the most successful of the series. The maintenance check which followed during the night, however, revealed that the truck required major overhaul before further runs could be attempted.

Appendix B

TOTAL DATA LOG FOR MEASUREMENT SERIES

This appendix provides a complete log of all data taken during the hot- and cold-weather runs.

COLD-WEATHER DATA

The numbers 1 through 24 refer to the thermocouple locations as shown in Fig. 4. The numbers 0100 through 2400 refer to the hour of the day in military time. As can be seen by the amount of continuous data, this program was highly successful. Usually in a program of this type about half the data is lost due to power outages, broken thermocouples, instrument malfunction and the like. A glance at Table 2 indicates two power outages: (1) when the motel manager unplugged the extension cord the first night on the road, and (2) the recorder malfunction on 3 February 1969.

HOT-WEATHER DATA

The numbers 1 through 12 refer to the thermocouple locations as shown in Fig. 5. Although these data are not as complete as the cold-weather data, they are adequate to allow the reader to obtain a firm feel for the severity of thermal exposure experienced by the ordnance.

TABLE 2. Cold-Weather Run Temperature Recordings.

30 January 1969

THERMOCOUPLE NUMBER	TIME OF DAY - HOUR 0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1							31	32	32	32	30	31	31	30	30	30	30	30						
2							31	32	32	32	30	31	31	30	30	30	30	30						
3							30	30	30	30	30	30	30	30	30	30	30	30						
4							28	29	30	30	30	30	30	30	30	30	30	30						
5							28	29	30	30	30	30	30	30	30	30	30	30						
6							27	29	30	30	30	32	31	30	32	32	51	30						
7							27	29	30	30	30	31	31	30	32	32	31	30						
8							28	29	30	30	30	31	31	30	32	32	32	31						
9							22	22	18	20	17	17	22	18	18	24	24	28						
10							24	28	29	30	30	30	30	31	33	30	28	28	27	Power Outage				
11							28	30	31	30	31	32	32	31	32	32	31	30	30					
12							31	32	33	33	33	33	33	33	33	33	32	32	32					
13							36	37	36	35	36	36	36	35	35	35	34	34	34					
14							24	28	28	29	28	30	30	32	32	30	28	28	26					
15							21	29	35	35	40	41	42	43	46	44	44	43	42					
16							29	30	31	31	31	31	31	31	32	31	31	31	30					
17							26	28	28	28	29	30	30	30	32	31	30	29	28					
18							24	26	28	28	28	29	29	30	30	30	30	29	28					
19							25	27	28	28	28	29	29	30	31	30	30	29	27					
20							25	27	28	28	28	29	29	30	30	30	30	29	28					
21							23	25	27	27	28	29	29	30	30	30	29	28	27					
22							23	25	27	27	28	29	29	30	30	30	30	29						
23							24	26	28	31	38	29	28	34	34	29	26	26						
24							22	28	30	36	43	33	36	33	36	39	32	30						

TABLE 2. (Continued).

31 January 1969

THERMOCOUPLE NUMBER	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1							17	17	17	17	17	18	18	19	20	21	22	22	24	24	25	26	26	26
2							17	17	17	17	17	18	18	19	20	21	22	22	24	24	25	26	26	26
3							16	16	16	16	16	17	18	19	20	22	23	24	24	25	26	26	26	26
4	Power Outage						14	14	15	16	16	18	20	22	24	24	25	26	26	26	26	26	27	27
5							14	14	14	15	16	18	20	22	24	24	25	26	26	26	26	28	27	27
6							11	12	13	15	18	21	22	26	28	28	28	28	28	28	28	28	28	28
7							11	12	13	15	17	20	20	24	26	27	27	28	28	28	28	28	28	28
8							12	12	13	14	15	18	20	22	24	26	26	28	28	28	28	28	28	28
9							6	-2	9	11	32	20	40	32	34	36	36	28	28	27	27	27	26	26
10							10	12	14	19	22	25	27	28	30	30	30	28	28	28	28	28	29	27
11							14	16	16	18	20	22	23	24	26	26	26	26	26	27	27	27	26	26
12							18	19	20	20	20	22	23	24	24	25	25	26	26	25	26	26	26	26
13							24	24	24	22	24	24	23	24	24	24	24	24	24	25	25	25	25	25
14							8	10	14	20	22	26	28	28	30	30	29	28	28	28	28	28	26	26
15							8	16	21	27	33	36	38	41	44	44	40	40	44	44	46	46	46	46
16							28	28	28	30	30	31	32	32	32	32	32	32	33	33	33	33	33	33
17							12	12	14	17	20	24	26	28	30	30	B	30	30	30	30	30	29	28
18							11	11	12	14	18	22	24	26	28	30	A	30	30	30	30	29	29	28
19							11	11	12	16	19	22	24	26	28	29	D	29	29	29	29	29	28	28
20							11	11	12	14	17	20	22	25	27	28		29	29	29	29	29	28	28
21							10	10	12	14	18	20	24	25	28	28	I	29	29	29	29	29	28	28
22							10	10	12	14	17	20	22	25	28	28	N	29	29	29	29	29	28	28
23							10	8	14	24	24	26	32	30	32	30	F	29	28	28	28	28	27	27
24							13	11	17	24	25	30	38	32	36	34	O	33	35	34	34	34	34	34

TABLE 2. (Continued).

1 February 1969

THERMOCOUPLE NUMBER	TIME OF DAY - HOUR 0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1	26	26	26	26	27	27	27	26	26	26	26	26	27	27	27	28	28	27	27	27	27	27	28	28
2	26	26	26	26	27	27	27	26	26	26	26	26	27	27	27	28	28	27	27	27	27	27	28	28
3	26	26	26	26	27	27	27	26	26	26	26	26	27	27	27	28	28	27	27	27	27	27	28	28
4	27	27	27	27	28	27	27	26	26	26	26	26	27	28	28	29	29	28	28	28	28	28	28	28
5	27	27	27	27	27	27	27	26	26	26	26	26	27	27	28	28	28	27	27	27	28	28	28	28
6	28	28	28	28	28	27	27	26	27	27	27	28	28	29	30	30	30	29	29	30	30	30	30	30
7	28	28	28	28	28	27	27	26	27	27	27	28	28	29	29	30	30	29	29	29	30	30	30	30
8	28	28	28	28	28	27	27	26	27	27	27	28	28	29	29	30	30	29	29	29	30	30	30	30
9	27	27	27	26	25	23	28	27	22	18	19	18	32	24	24	30	30	30	32	32	30	32	28	27
10	27	28	28	28	26	25	25	27	26	26	28	28	28	29	30	29	29	29	29	29	27	28	28	27
11	26	26	26	26	26	26	26	26	26	26	26	26	27	28	28	28	28	27	27	28	28	28	28	27
12	26	26	26	26	26	26	26	26	26	26	26	26	27	27	27	28	28	27	27	27	27	27	28	27
13	25	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	27	26	25	26	26	26	26	26
14	27	28	28	27	26	25	26	27	26	26	28	28	29	29	29	30	30	29	29	30	28	29	28	27
15	46	46	46	46	46	44	42	40	40	40	41	40	42	42	44	43	42	40	42	44	46	45	46	45
16	33	33	33	33	33	33	32	32	32	32	32	32	32	32	32	32	32	32	31	31	31	31	31	31
17	28	28	28	28	28	27	27	27	27	28	27	28	28	29	30	30	30	28	28	29	29	29	29	29
18	28	28	28	28	28	27	27	27	27	27	26	27	27	28	28	28	29	28	28	28	28	28	28	28
19	28	28	28	28	28	27	27	27	27	27	27	28	28	29	29	30	30	28	28	29	29	29	28	28
20	28	28	28	28	28	27	27	27	27	27	27	28	28	29	29	30	30	28	28	29	29	29	29	29
21	28	28	28	28	28	27	26	26	26	26	27	27	28	28	29	29	29	28	28	29	28	28	28	28
22	28	28	28	28	28	27	26	26	26	27	27	27	28	28	29	30	29	28	28	29	29	29	29	29
23	28	28	28	27	27	25	26	27	25	26	30	23	30	28	29	30	31	29	30	30	29	30	28	27
24	34	36	36	33	32	28	26	28	27	23	34	27	31	31	29	31	33	32	33	33	33	33	35	35

TABLE 2. (Continued).

2 February 1969

THERMOCOUPLE NUMBER	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1	28	28	28	28	28	28	28	28	28	28	28	29	30	30	30	30	31	31	30	30	30	30	30	30
2	28	28	28	28	28	28	28	28	28	28	28	29	30	30	30	30	31	31	30	30	30	30	30	30
3	28	28	28	28	28	28	28	28	28	28	28	29	30	30	31	31	31	31	30	30	30	30	30	30
4	28	28	28	28	28	28	28	28	28	29	30	31	32	32	32	32	31	31	30	30	30	30	30	30
5	28	28	28	28	28	28	28	28	28	29	30	31	32	32	32	32	31	30	30	30	30	30	29	29
6	30	29	29	29	29	29	29	29	30	30	32	33	33	32	32	32	32	31	30	30	30	30	29	29
7	30	29	29	29	29	29	29	29	29	30	31	32	32	32	32	32	32	31	30	30	30	30	29	29
8	30	29	29	29	29	29	29	29	29	30	30	32	32	32	32	32	32	32	30	30	30	30	30	29
9	27	29	31	31	28	30	30	32	36	36	38	35	30	27	29	26	26	24	25	25	26	25	28	31
10	27	27	28	29	29	28	29	30	32	33	36	34	33	31	32	30	30	30	30	30	30	30	30	30
11	27	27	27	28	28	28	28	28	29	30	31	31	31	31	31	30	30	30	30	30	30	31	30	29
12	27	27	27	28	28	28	28	28	28	29	29	30	30	30	30	30	30	30	30	30	30	30	30	29
13	26	26	26	26	27	27	27	27	27	27	27	28	28	29	29	29	29	29	29	30	30	30	30	29
14	26	27	28	29	28	28	29	30	32	34	36	34	32	31	32	29	29	29	29	30	30	30	30	30
15	44	44	45	46	46	46	46	46	47	47	48	48	46	44	46	44	43	44	46	46	46	46	46	46
16	31	31	31	31	31	31	31	31	31	31	32	32	32	32	32	32	31	31	31	31	31	31	31	31
17	28	28	28	28	28	28	28	28	29	31	32	33	33	32	32	31	30	30	30	29	29	29	29	29
18	28	27	27	28	28	28	28	28	29	30	31	32	33	32	32	31	30	30	30	30	30	30	29	29
19	28	28	28	28	28	28	28	29	30	31	32	33	32	32	32	31	30	30	30	30	30	30	29	29
20	28	28	28	28	28	28	28	29	29	30	31	32	32	32	32	32	31	31	30	30	30	30	29	29
21	27	27	28	28	28	28	28	29	30	31	32	33	32	32	32	31	30	30	30	30	30	29	29	29
22	28	28	28	28	28	28	28	29	29	30	32	33	33	33	32	32	31	31	30	30	30	29	29	29
23	27	28	29	30	28	29	29	31	34	34	37	34	31	30	30	29	29	29	29	29	29	23	29	30
24	33	31	32	33	34	33	33	33	35	32	39	31	28	28	28	33	38	39	40	40	38	37	36	36

TABLE 2. (Continued).

3 February 1969

TIME OF DAY - HOUR

THERMOCOUPLE NUMBER	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1	30	30	30	30	30	30	30	30	30	30			32				33	34	34	34	34	34	34	33
2	30	30	30	30	30	30	30	30	30	30			32				33	34	34	34	34	34	33	33
3	30	30	30	30	30	30	30	30	30	30	Recorder		32	Recorder			33	34	34	34	34	34	33	33
4	30	30	30	30	30	30	30	30	31	32			33				34	34	34	34	34	34	33	33
5	30	30	30	30	30	30	30	30	31	32			33				34	34	34	34	34	33	33	32
6	30	30	30	30	30	30	31	32	32	33	Malfunc-tion		34	Malfunction			34	34	34	34	34	33	32	32
7	30	30	30	30	30	30	30	31	32	32			34				34	34	34	34	34	33	32	32
8	30	30	30	30	30	30	30	31	31	32			34				34	34	34	34	34	34	33	32
9	32	31	31	32	32	32	32	34	36	34			34				34	34	34	33	33	30	29	28
10	30	31	31	32	32	32	32	32	33	34			36				35	34	34	34	33	33	32	32
11	30	30	30	30	30	30	30	30	31	32			34				34	34	34	33	33	33	32	32
12	30	30	30	30	30	30	30	30	31	32			33				34	34	34	33	33	33	33	32
13	30	30	30	30	30	30	30	30	30	30			31				32	32	32	32	32	32	32	32
14	30	31	31	31	31	32	32	32	33	34			36				34	34	34	34	34	32	32	31
15	48	48	49	49	49	50	49	48	56	45			48				46	48	49	49	50	49	49	48
16	31	31	31	31	31	31	31	32	32	32			32				32	32	32	32	32	32	32	32
17	29	30	30	30	30	30	30	31	32	33			34				34	34	33	33	33	32	32	31
18	30	30	30	30	30	30	30	31	32	32			34				34	34	34	34	34	33	32	32
19	30	30	30	30	30	30	30	31	32	32			34				34	34	34	34	34	33	32	32
20	30	30	30	30	30	30	30	31	32	32			34				34	34	34	34	34	33	33	32
21	30	30	30	30	30	30	30	31	32	32			34				34	34	34	34	34	33	33	32
22	30	30	30	30	30	30	30	31	32	32			34				34	34	34	34	34	34	33	32
23	31	31	31	32	32	32	33	33	34	34			36				34	34	34	34	33	32	31	30
24	37	38	37	38	38	38	38	32	36	32			34				36	36	36	36	36	35	39	39

TABLE 2. (Continued).

4 February 1969

THERMOCOUPLE NUMBER	TIME OF DAY - HOUR 0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1	33	33	32	32	31	30	29	28	28	28	28	28	28	28	28	28	28	28	27	27	27	26	26	25
2	33	33	32	32	31	30	29	28	28	28	28	28	28	28	28	28	28	28	27	27	27	26	26	25
3	33	32	32	31	30	30	28	28	27	26	27	27	27	28	28	28	28	28	27	27	26	25	25	24
4	33	32	32	31	30	28	27	26	26	26	27	28	28	28	28	28	28	27	26	26	25	25	24	24
5	32	32	31	30	29	28	26	26	25	26	27	27	28	28	28	28	27	27	26	25	25	24	24	24
6	32	31	30	29	28	26	25	24	24	26	28	28	29	29	28	28	27	26	25	24	24	23	22	22
7	32	31	30	30	28	27	25	24	24	26	27	28	28	29	28	28	27	26	25	24	24	23	22	22
8	32	32	31	30	30	28	26	26	25	25	26	27	28	29	28	28	28	27	26	26	25	24	24	23
9	27	25	23	18	18	17	18	20	22	31	30	26	33	23	22	21	21	20	20	20	20	19	18	19
10	31	30	29	27	26	24	24	23	23	28	29	30	30	29	28	27	26	26	25	24	24	24	24	23
11	32	31	30	30	28	27	26	26	26	28	28	29	30	29	28	28	28	27	26	26	26	25	25	24
12	32	32	32	31	30	30	30	28	28	28	28	29	30	30	29	29	29	28	28	28	27	27	26	26
13	32	32	32	32	32	31	31	30	30	30	30	30	30	30	29	29	29	29	29	29	28	28	28	28
14	30	30	28	26	24	23	23	22	22	28	29	30	30	28	27	26	26	24	24	23	23	23	23	22
15	48	47	46	44	42	40	48	46	46	38	41	42	44	44	41	42	42	42	40	40	40	40	40	40
16	32	32	31	31	30	30	30	30	30	30	30	31	31	31	30	30	30	30	30	30	30		29	29
17	30	30	29	28	26	25	24	24	24	26	28	29	29	29	28	28	27	26	25	24	24	23	23	22
18	32	31	30	30	28	27	26	24	24	25	26	28	28	28	28	28	27	26	26	25	24	24	24	23
19	31	31	30	28	27	25	24	24	24	26	27	28	29	28	28	28	27	26	26	25	24	24	23	23
20	32	31	30	30	28	27	25	24	24	25	26	28	28	28	28	28	27	26	26	25	24	24	24	23
21	32	31	30	28	26	25	24	23	23	25	26	28	28	28	28	28	26	26	25	24	24	23	23	22
22	32	31	30	30	28	26	24	24	23	25	26	28	28	28	28	28	27	26	25	25	24	24	23	23
23	30	29	27	25	23	21	21	21	21	30	30	28	32	27	27	26	25	24	23	22	22	22	22	22
24	36	35	34	34	31	27	25	20	19	31	31	27	34	26	32	31	30	30	28	27	26	27	28	26

TABLE 2. (Continued).

5 February 1969

THERMOCOUPLE NUMBER	TIME OF DAY - HOUR																							
	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1	25	24	24	24	24	23	23	23	22	22	22	22	22	22	22	22	22	22	22	22	22	21	20	20
2	25	24	24	24	24	23	23	23	22	22	22	22	22	22	22	22	22	22	22	22	22	21	20	20
3	24	24	23	23	23	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	21	20	19	18
4	24	23	23	23	23	22	22	22	22	22	22	22	22	22	23	22	22	22	22	21	20	20	18	18
5	23	23	22	22	22	22	22	22	22	21	21	22	22	22	22	22	22	22	21	21	20	19	18	17
6	22	21	21	21	21	20	20	20	21	21	21	22	23	24	24	23	23	22	21	20	19	18	17	16
7	22	21	21	21	21	20	20	20	20	21	21	22	22	23	24	23	23	22	22	20	19	18	17	16
8	22	22	22	21	21	20	20	20	20	21	21	22	22	23	24	23	23	23	23	22	21	20	18	17
9	19	19	18	18	18	18	18	18	20	14	19	25	31	20	20	18	15	14	12	10	9	8	5	6
10	23	23	22	22	22	22	22	22	22	21	22	23	26	24	23	23	22	21	20	19	18	17	16	15
11	24	24	24	23	23	23	23	23	23	22	22	23	24	24	23	23	23	22	22	21	20	20	18	18
12	26	26	25	25	25	24	24	24	24	24	24	24	24	24	24	24	24	24	24	23	22	22	21	20
13	28	27	24	26	26	26	26	26	26	25	25	24	24	24	24	24	24	24	24	24	24	24	23	23
14	22	22	22	22	22	22	22	22	22	20	21	23	26	24	22	22	21	20	20	18	16	16	14	14
15	39	39	39	39	39	39	39	39	37	36	34	35	38	37	35	35	36	36	36	35	34	33	32	30
16	29	29	29	29	28	28	28	28	28	28	27	27	27	27	26	26	26	26	25	25	24	23	22	21
17	22	22	22	22	22	22	22	22	22	22	21	22	23	24	23	22	22	22	21	20	19	18	16	16
18	23	22	22	22	22	22	22	22	22	22	21	21	22	23	23	22	22	22	21	21	20	18	18	18
19	23	22	22	22	22	22	22	22	22	21	21	21	24	23	23	22	22	22	21	21	20	18	18	18
20	23	22	22	22	22	22	22	22	22	22	21	21	22	23	23	22	22	22	22	21	20	19	18	18
21	22	22	22	22	22	22	22	22	22	21	21	21	23	23	22	22	22	22	21	20	18	17	16	15
22	22	22	22	22	22	22	22	22	22	21	21	21	22	23	23	22	22	22	21	20	19	18	16	15
23	22	22	22	22	22	22	22	22	22	20	21	24	26	22	22	22	20	20	18	18	16	15	13	12
24	27	27	28	26	30	28	26	29	20	16	21	24	24	21	22	25	21	24	18	19	22	24	28	19

TABLE 2. (Continued).

6 February 1969

THERMOCOUPLE NUMBER	TIME OF DAY - HOURS																							
	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1	19	18	18	17	16	16	15	14	12	11	10	9	8	8	8	8	8	8	8	8	8	8	8	8
2	19	18	18	17	16	16	15	14	12	11	10	9	8	8	8	8	8	8	8	8	8	8	8	8
3	18	17	16	16	15	14	13	13	11	10	8	7	6	6	6	7	7	7	8	8	8	8	8	7
4	17	16	15	15	14	14	13	12	10	8	6	5	6	6	7	7	7	7	8	8	8	8	8	7
5	16	15	15	14	14	13	12	11	9	7	5	5	5	6	6	7	7	7	8	8	8	8	7	7
6	15	14	13	12	11	11	10	10	6	3	2	3	5	7	8	8	9	9	9	9	9	9	8	8
7	15	14	13	12	11	11	10	10	7	4	3	3	4	6	7	8	8	9	9	9	9	9	8	8
8	16	15	14	13	12	12	11	10	9	7	4	4	4	6	7	7	8	9	9	9	9	9	9	9
9	4	6	7	4	5	5	4	0	-20	-20	-6	3	8	7	8	7	7	6	6	6	2	0	2	0
10	14	14	14	14	13	12	12	9	4	1	3	4	8	7	9	9	9	9	9	9	8	7	7	6
11	17	16	16	16	15	14	14	13	10	8	7	7	8	9	10	10	10	10	10	10	10	9	9	8
12	20	19	19	18	18	17	16	16	14	13	11	11	11	13	12	11	11	11	11	11	11	11	10	10
13	22	22	22	21	20	20	19	19	18	18	16	16	15	15	14	14	14	13	13	13	12	12	12	12
14	13	13	13	12	12	12	11	8	0	-1	2	3	8	8	9	8	9	9	9	9	8	7	7	6
15	30	30	29	29	28	28	27	21	14	11	12	12	18	18	20	19	20	21	22	22	23	22	22	22
16	20	19	18	18	17	17	16	14	10	9	7	7	8	8	8	8	8	8	8	8	8	8	8	8
17	15	14	13	13	12	12	12	10	4	0	0	1	5	6	8	8	8	8	8	8	8	8	7	7
18	16	15	14	14	13	12	12	10	5	2	0	1	3	5	6	7	7	7	8	8	8	8	7	7
19	16	15	14	14	13	13	12	10	4	2	1	2	5	5	7	7	8	7	8	8	8	8	7	7
20	16	15	14	14	13	13	12	11	8	4	2	2	3	5	6	7	8	7	8	8	8	8	7	7
21	14	13	13	12	11	12	10	8	4	2	0	1	4	5	6	7	7	7	8	8	7	7	6	6
22	14	13	13	12	12	12	11	10	6	4	1	1	3	4	6	7	7	7	8	8	8	7	7	6
23	12	12	12	10	10	12	8	4	-2	-6	-3	3	7	7	8	7	8	8	8	8	6	5	5	4
24	20	19	21	20	20	17	10	2	-4	-7	-4	5	7	8	8	7	9	10	13	14	10	6	8	10

TABLE 2. (Continued). 7 February 1969

THERMOCOUPLE NUMBER	TIME OF DAY - HOURS 0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1	7	7	6	6	5	4	3	2	2	2	3	4	6	7	8	10	11	12	13	14	14	14	14	14
2	7	7	6	6	5	4	3	2	2	2	3	4	6	7	8	10	11	12	13	14	14	14	14	14
3	7	7	6	5	4	3	2	3	1	1	2	4	6	8	10	11	13	14	14	15	15	14	14	14
4	7	6	5	4	3	1	1	0	0	2	5	8	10	12	13	14	16	16	16	16	15	14	14	14
5	6	6	5	3	2	1	0	0	0	2	5	8	10	12	13	14	16	16	16	15	15	14	14	13
6	7	6	4	3	2	0	-2	-2	0	4	9	12	16	18	20	21	22	20	20	20	19	18	17	16
7	7	6	5	3	2	0	-1	-2	0	2	6	10	14	16	18	20	21	20	20	20	19	18	17	16
8	8	7	6	5	4	2	0	0	0	1	4	7	10	14	17	18	20	20	21	20	20	[illegible]	18	18
9	-2	-4	-9	-10	-11	-12	-7	-8	17	28	40	24	27	32	13	32	[illegible]	15	12	11	10	8	8	8
10	6	4	3	1	0	-1	-1	-1	5	13	16	20	21	23	19	23	21	17	16	15	14	13	12	12
11	8	7	6	4	3	2	2	2	3	7	10	12	14	16	16	17	18	16	16	15	14	14	13	13
12	10	9	8	8	7	6	4	4	4	6	7	9	11	12	13	14	16	15	15	15	14	14	14	14
13	12	11	11	10	10	9	8	8	8	7	7	8	8	8	9	10	11	11	12	12	12	12	13	13
14	[illegible]	3	1	-1	-2	-3	-2	-2	6	14	17	21	22	24	18	24	20	17	16	14	14	12	12	11
15	21	20	18	16	14	12	11	12	14	23	29	33	35	38	36	36	36	33	32	32	32	30	30	30
16	7	6	5	5	4	3	2	2	3	5	7	10	13	14	15	17	18	17	17	16	16	16	15	14
17	6	5	3	2	0	-1	-2	-2	1	5	10	13	16	17	19	20	22	20	18	17	16	15	14	13
18	6	5	4	3	2	0	-1	-1	0	3	7	10	13	15	17	18	20	20	19	18	17	16	15	14
19	6	5	4	3	2	0	0	-1	1	5	9	12	14	16	16	19	19	19	18	17	16	16	15	14
20	7	6	5	4	3	0	0	-1	0	2	5	8	11	14	16	17	20	20	19	18	17	16	16	15
21	5	4	3	1	0	-2	-3	-3	0	5	9	13	16	18	18	20	20	20	18	17	16	14	14	12
22	6	5	4	2	0	-2	-2	-3	-1	2	7	10	14	16	18	19	20	20	19	18	16	15	14	13
23	3	1	-1	-3	-4	-6	-2	-4	9	22	21	24	22	26	18	28	15	17	15	14	12	12	11	10
24	3	10	5	8	-7	-4	-2	-4	-2	25	21	20	20	24	22	32	9	23	19	21	18	18	15	16

TABLE 2. (Continued).

8 February 1969

TIME OF DAY - HOURS

THERMOCOUPLE NUMBER	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1	14	14	13	13	12	12	11	10	10	11	12	13	14	16	17	18	18	19	19	19	19	19	19	19
2	14	14	13	13	12	12	11	10	10	11	12	13	14	16	16	17	18	19	19	19	19	19	19	19
3	14	13	12	12	11	11	10	10	10	10	12	13	15	17	18	19	19	20	20	20	20	19	18	18
4	13	12	12	12	11	10	10	10	10	12	14	16	18	20	20	20	21	20	20	20	20	19	19	18
5	13	12	11	11	10	9	9	9	10	12	14	16	18	20	20	20	21	20	20	19	19	18	18	18
6	15	14	13	12	12	11	11	11	13	16	19	22	24	24	24	24	24	24	23	22	22	20	20	20
7	15	14	13	13	12	11	11	11	13	14	17	20	22	23	24	24	24	24	23	22	22	20	20	20
8	16	16	15	14	13	12	11	11	12	13	15	18	20	22	24	24	24	24	24	23	23	22	21	20
9	7	8	4	6	6	8	7	12	4	30	36	38	27	26	21	24	18	18	17	15	14	15	19	17
10	11	10	10	9	8	8	9	11	13	18	22	26	26	24	24	24	21	20	20	18	18	18	18	18
11	12	12	11	10	10	10	10	10	12	14	16	19	21	21	20	21	20	20	19	18	18	18	18	18
12	13	13	12	12	12	12	11	11	12	13	14	16	17	18	18	19	19	19	19	18	18	18	18	18
13	13	13	13	13	12	12	12	11	12	12	12	13	14	14	15	15	16	16	16	16	17	17	17	17
14	10	9	9	8	8	8	9	11	13	18	22	26	26	24	24	24	21	20	19	18	17	17	18	18
15	29	28	28	26	26	26	26	25	25	20	36	38	40	39	39	38	38	38	38	36	36	35	36	36
16	14	14	13	12	11	11	11	11	12	14	16	20	21	21	22	22	22	22	21	20	20	20	20	20
17	12	11	10	10	9	9	9	9	12	15	18	20	25	25	24	24	23	22	21	20	20	18	18	18
18	13	12	11	10	10	9	9	9	11	14	16	20	23	24	24	24	24	22	22	21	21	20	20	19
19	14	12	11	10	10	10	9	11	12	15	18	21	23	23	23	24	24	22	22	21	20	20	20	19
20	11	13	12	11	10	10	10	9	11	13	15	18	21	22	23	24	24	22	23	22	22	20	20	20
21	12	10	10	9	8	9	9	9	11	14	18	21	21	24	24	24	23	22	21	20	19	18	18	18
22	12	11	10	10	9	9	9	9	11	13	16	20	22	24	24	24	23	22	22	21	20	19	18	18
23	10	8	8	7	7	10	8	16	13	25	30	30	26	26	23	23	21	20	19	18	17	17	18	17
24	15	15	18	12	15	14	13	18	13	25	28	30	24	28	22	26	28	26	26	23	21	24	24	24

TABLE 2. (Continued).

9 February 1969

THERMOCOUPLE NUMBER	TIME OF DAY - HOURS 0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1	19	18	18	18	18	18	18	18	19	19	20	21	22	23	24	26	27	27	28	28	28	29	28	28
2	19	18	18	18	18	18	18	18	19	19	20	21	22	23	24	26	27	27	28	28	28	29	28	28
3	18	18	18	18	18	18	18	18	19	20	21	22	23	24	26	28	29	29	29	29	29	29	28	28
4	18	18	18	18	18	18	18	20	21	22	23	24	25	27	29	31	31	31	30	30	29	29	28	28
5	18	18	18	18	18	18	18	19	20	22	23	24	25	27	29	31	31	31	30	30	29	29	28	28
6	20	18	18	18	18	18	19	21	23	24	26	27	29	32	36	36	34	34	33	32	31	30	30	29
7	20	18	18	18	18	18	19	20	22	23	25	26	28	30	34	36	34	34	33	32	31	30	30	29
8	20	20	19	19	18	18	18	20	21	22	24	25	27	28	31	34	35	34	34	33	33	32	31	30
9	14	16	19	18	20	21	22	28	32	38	36	22	37	51	47	28	26	26	28	25	26	28	26	24
10	17	17	18	18	19	19	20	24	24	28	28	29	32	37	38	34	32	31	29	28	27	24	27	26
11	17	17	18	18	18	18	18	20	22	23	24	25	27	29	31	31	30	30	28	28	27	27	27	26
12	18	17	18	18	18	18	18	19	20	21	22	23	24	25	27	28	28	28	28	28	27	27	27	26
13	17	17	18	18	18	18	18	18	18	18	19	20	20	20	21	22	23	23	24	24	25	25	25	25
14	17	17	18	18	18	20	20	25	25	29	30	30	33	38	40	34	32	31	29	28	27	27	26	25
15	36	35	36	36	37	38	38	39	40	42	44	46	47	50	54	50	46	46	44	44	44	44	44	44
16	20	20	20	20	20	20	20	21	22	23	24	25	26	28	30	30	30	30	29	29	28	28	28	28
17	18	18	18	18	18	18	19	21	24	24	26	27	28	30	34	34	33	33	31	30	29	28	28	27
18	19	18	18	18	18	18	19	20	22	23	24	26	27	29	32	34	34	34	32	31	30	30	28	28
19	19	18	18	18	18	19	19	21	23	24	26	26	28	30	34	32	32	32	31	30	30	29	28	28
20	19	18	18	18	18	18	18	20	22	22	24	25	26	27	30	32	32	32	32	31	30	30	29	29
21	18	18	18	18	18	18	19	21	22	24	26	27	29	32	34	34	33	33	32	30	29	29	28	27
22	18	18	18	18	18	18	18	20	22	23	25	27	28	30	33	32	32	32	32	31	30	30	29	28
23	16	17	18	18	19	22	21	26	28	34	32	29	35	42	43	31	29	29	28	27	27	26	26	25
24	18	20	21	22	21	24	24	28	28	34	32	26	32	44	44	30	29	28	30	30	29	30	30	28

TABLE 2. (Continued).

10 February 1969

THERMOCOUPLE NUMBER	TIME OF DAY - HOURS 0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1	28	28	28	27	26	26	26	26	25	26	26	27	28	29	30	31	32	32	34	34	34	33	32	31
2	28	28	28	27	26	26	26	26	25	26	26	27	28	29	30	31	32	32	34	34	34	33	32	31
3	28	28	27	26	26	25	25	24	24	25	26	27	29	30	32	32	31	33	34	34	34	32	31	30
4	28	27	26	26	25	25	24	24	25	26	28	30	32	34	34	34	34	34	34	33	32	31	30	28
5	27	26	26	25	24	24	24	24	24	26	28	30	32	34	34	34	34	34	34	32	31	30	29	27
6	28	27	26	25	24	24	24	25	26	28	30	34	37	37	38	38	38	36	35	34	33	32	29	27
7	28	28	27	26	25	24	24	25	26	28	29	32	35	36	38	38	38	36	36	34	33	32	30	28
8	29	29	28	27	26	25	25	25	26	27	28	30	32	34	37	38	38	37	38	36	35	34	32	30
9	22	21	20	20	22	24	27	28	31	38	44	46	45	42	39	40	18	24	24	26	19	17	10	4
10	25	24	23	22	22	24	24	27	28	32	35	39	40	38	38	37	32	30	30	29	28	26	24	21
11	26	25	25	24	24	24	24	25	26	28	29	32	34	34	34	34	33	31	32	31	30	29	28	26
12	26	26	26	26	25	25	25	25	25	26	27	29	30	31	31	32	32	31	32	32	32	31	30	29
13	26	26	26	26	26	25	25	25	25	25	25	26	26	27	26	28	29	29	31	32	32	32	32	31
14	24	24	23	22	22	23	25	27	28	32	37	40	40	38	37	38	31	30	29	28	27	25	22	20
15	44	43	42	42	42	42	42	42	41	42	46	51	54	54	53	52	50	46	44	44	45	45	42	39
16	28	27	27	26	26	26	26	26	27	29	31	30	31	31	31	31	31	30	31	31	31	31	30	30
17	26	25	25	24	23	23	23	24	26	29	32	34	36	37	36	36	35	32	32	31	30	28	27	25
18	27	26	25	24	24	23	23	24	25	27	29	32	35	36	36	36	36	34	34	32	31	29	27	26
19	27	26	25	25	24	24	24	25	26	28	30	34	35	36	36	36	34	33	34	32	31	30	28	26
20	28	27	26	26	25	24	24	24	25	26	28	30	33	34	35	35	36	34	34	34	32	31	30	27
21	26	25	24	23	23	23	23	24	26	28	32	34	36	36	37	37	34	33	32	30	29	27	25	22
22	27	26	25	24	23	23	23	24	25	28	30	33	35	36	37	37	36	34	34	32	30	28	26	24
23	24	23	22	21	22	23	26	27	29	34	41	42	44	38	36	37	28	28	28	27	25	23	19	16
24	27	27		26	26	27	29	28	32	36	46	42	40	38	37	38	25	33	36	31	34	34	29	14

TABLE 2. (Continued).

11 February 1969

Thermocouple number	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1	30	28	27	25	23	21	19	17	16	16	16	16	18	19	20	21	23	24	26	27	28	29	30	30
2	30	28	27	25	23	21	19	17	16	16	16	16	18	19	20	21	23	24	26	27	28	29	30	30
3	28	27	25	23	21	19	17	15	14	14	14	16	18	20	21	23	24	26	27	29	30	30	31	32
4	26	24	22	20	19	17	15	13	12	14	16	19	21	22	24	25	27	28	30	31	32	32	32	33
5	25	23	21	19	17	16	14	12	12	13	16	19	21	22	24	25	27	28	30	31	32	32	32	33
6	24	22	20	17	15	13	11	10	12	15	22	24	26	28	29	30	32	35	36	37	38	38	38	38
7	25	23	20	18	16	14	12	10	11	13	18	21	24	26	28	29	31	33	35	36	37	38	38	38
8	28	26	23	20	18	16	14	12	11	12	14	18	22	24	26	28	29	31	34	35	36	37	38	38
9	10	4	-2	-2	-2	-6	-6	17	24	28	36	26	30	46	34	32	49	42	40	40	38	37	36	37
10	20	18	16	14	12	11	10	10	15	19	28	29	28	30	32	32	36	36	35	36	35	35	34	35
11	24	23	21	20	18	17	15	14	15	17	22	24	24	26	28	28	30	31	32	32	32	32	32	33
12	28	27	26	24	23	21	20	18	18	19	20	22	23	24	25	26	27	28	29	30	30	30	31	31
13	30	30	30	29	28	27	26	24	24	23	22	22	23	23	23	24	24	24	25	26	26	27	27	28
14	28	16	14	12	10	9	8	10	15	20	19	29	28	30	32	33	37	36	36	36	35	35	35	35
15	37	35	32	30	29	27	22	20	26	28	36	39	40	42	45	45	49	52	52	53	53	52	52	52
16	29	28	27	25	24	22	19	18	18	18	20	22	24	24	26	27	28	29	30	30	30	30	31	31
17	23	22	20	18	16	14	11	10	12	15	20	20	25	27	30	30	32	32	33	34	34	34	34	34
18	23	22	19	16	15	13	10	9	10	13	18	20	24	26	28	30	32	32	33	34	34	34	34	34
19	24	22	19	16	15	12	11	10	12	15	22	20	25	26	28	30	32	32	33	34	34	34	34	34
20	25	23	20	18	16	14	12	10	10	13	17	20	23	25	27	28	30	31	33	34	34	34	34	34
21	20	18	15	12	11	9	7	7	9	13	20	20	24	26	28	30	32	33	34	34	34	34	34	35
22	21	19	16	14	14	14	10	7	8	12	17	21	23	25	28	29	31	32	34	34	34	35	35	35
23	16	12	10	9	7	5	6	10	20	24	28	28	29	35	28	33	46	38	37	37	35	35	35	36
24	16	23	20	18	17	6	5	10	17	25	26	26	27	30	25	34	47	40	40	42	41	40	40	41

TABLE 2. (Continued).

12 February 1969

THERMOCOUPLE NUMBER	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1	31	32	32							36							42							51
2	31	32	32							36							42							51
3	32	32	33							36							43							52
4	33	34	34							38							47							53
5	33	34	34							38							47							53
6	38	38	38							42							55							58
7	38	38	38							40							53							58
8	38	38	38							44							50							59
9	37	37	38							43							62							57
10	35	35	36							38							57							54
11	33	33	34							36							49							51
12	31	32	32							36							43							49
13	29	29	29							32							36							44
14	35	35	36							44							58							54
15	52	53	53							55							68							72
16	31	31	32							34							38							38
17	34	34	34							40							52							55
18	35	35	35							40							52							54
19	35	35	35							40							54							54
20	35	35	35							40							50							54
21	35	35	35							40							54							55
22	35	35	35							40							52							55
23	36	36	36							44							60							55
24	42	40	42							45							60							60

TABLE 2. (Continued).

13 February 1969

THERMOCOUPLE NUMBER	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1							52							52										
2							52							52										
3							52							52										
4							52							53										
5							52							53										
6							54							55										
7							54							54										
8							56							54										
9							50							56										
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13							48							49										
14							50							58										
15							66							57										
16							38							43										
17							46							52										
18							50							54										
19							50							54										
20							51							52										
21							50							54										
22							51							54										
23							50							56										
24							53							55										

TABLE 3. First Day Hot-Weather Run Data.

7 August 1969

THERMOCOUPLE NUMBER	TIME OF DAY - HOUR 0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1		84	84	84	86	89	92	93	95	97	100	102	102					
2		78	78	81	83	87	91	94	97	102	107	108	108					
3		78	78	80	82	86	90	94	98	102	107	108	108					
4		78	78	80	82	86	90	94	97	101	107	108	108					
5		78	78	80	82	86	90	94	98	102	107	108	108					
6		79	79	83	94	98	103	104	112	108	110	120	112					
7		82	82	82	90	103	112	112	116	107	110	112	110					
8		82	82	83	86	94	89	101	104	104	106	107	107					
9		90	90	89	88	87	87	87	88	89	92	94	95					
10		83	83	84	90	94	97	100	100	102	104	104	105					
11		78	79	81	84	89	92	95	99	102	106	107	109					
12		78	79	81	84	88	91	94	98	100	105	107	108					

TABLE 4. Second Day Hot-Weather Run Data.

8 August 1969

Thermocouple number	Time of day - hour: 0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1						93	96	96	100	104	105	106	108	107	106			
2						90	98	100	104	109	112	114	115	113	110			
3						92	98	100	104	108	112	114	115	114	110			
4						92	98	100	103	107	111	114	115	114	111			
5						92	98	100	104	108	112	114	115	114	111			
6						106	105	98	121	126	122	118	112	107	103			
7						109	104	103	115	118	120	117	114	108	105			
8						100	100	101	108	111	114	114	113	110	108			
9						91	92	92	92	93	94	96	98	100	102			
10						97	98	99	103	107	109	110	111	108	107			
11						94	98	101	104	108	112	114	116	115	113			
12						93	97	100	103	107	111	114	116	116	114			

TABLE 5. Third Day Hot-Weather Run Data.

9 August 1969

THERMOCOUPLE NUMBER	TIME OF DAY - HOUR 0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1			94	96	98	99	100	101	105	107	109	109						
2			89	92	96	99	101	102	105	108	111	113						
3			88	91	94	98	100	102	105	108	111	113						
4			88	91	94	97	100	102	105	108	111	113						
5			88	91	94	97	100	102	105	108	111	113						
6			95	98	102	104	94	124	117	118	119	116						
7			97	108	102	104	107	118	118	124	123	120						
8			94	98	98	101	103	106	110	113	114	114						
9			96	96	95	95	95	95	95	96	98	99						
10			93	96	97	99	100	103	106	108	110	111						
11			88	90	93	96	99	101	105	108	111	113						
12			88	90	92	95	98	100	104	107	110	112						

TABLE 6. Fourth Day Hot-Weather Run Data.

12 August 1969

Thermocouple number	Time of day - hour: 0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1		84	85	86	POWER OUTAGE	94	97	98	98									
2		81	84	85		94	100	103	102									
3		81	82	84		93	100	102	102									
4		81	82	85		92	98	100	102									
5		81	82	83		94	99	102	102									
6		84	86	98		111	122	113	111									
7		82	86	91		104	114	110	111									
8		84	85	86		98	104	105	105									
9		87	87	85		86	87	88	88									
10		84	85	86		94	99	101	101									
11		82	83	86		94	99	101	101									
12		82	83	85		92	98	100	100									

TABLE 7. Fifth Day Hot-Weather Run Data.

13 August 1969

THERMOCOUPLE NUMBER	TIME OF DAY - HOUR 0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
1	87	87	88	90	91	95	97	101	102	104	106	107	107	104				
2	80	82	84	87	91	94	98	105	108	111	113	114	114	111				
3	80	80	82	85	88	92	96	104	107	111	113	114	115	112				
4	80	82	83	85	88	92	95	103	106	110	112	114	115	113				
5	79	80	82	84	88	92	95	103	107	111	113	114	115	112				
6	79	86	94	95	96	112	129	130	117	118	118	123	114	93				
7	82	86	92	93	95	105	115	115	115	116	117	116	114	103				
8	85	85	87	90	92	99	104	107	110	112	113	114	113	108				
9	92	92	91	90	90	89	89	90	92	94	95	97	99	101				
10	86	86	87	89	91	95	98	103	106	108	109	110	110	107				
11	81	82	83	85	88	92	96	103	107	110	113	114	116	114				
12	82	82	82	84	88	91	94	102	106	110	113	114	116	116				

Appendix C

METEOROLOGY OF INTEREST

It is always of interest, and in cases of reconstruction mandatory, to provide meteorological data with measured environmental information. As can be readily seen, the job of providing a complete set of weather data for a moving vehicle is a monumental task. Therefore, the next best thing is herein presented. The information in Fig. 16 through 20 were reprinted from the daily weather summary of the Los Angeles Times. They are covered by copyright, 1969, by the Los Angeles Times, and are herein reprinted by written permission (Fig. 21).

It can be seen by a quick look at Fig. 16 through 20 that the states of interest were involved with seasonal storms and storm fronts during the time of interest.

The air temperatures of interest, though not taken under approved U. S. Weather Bureau procedures nor conditions can be found in Appendix A, thermocouple Number 9. If a more complete reconstruction of meteorology is required, it can be obtained from official U. S. Weather Bureau records at the National Weather Records Center, Asheville, North Carolina.

The maps of Fig. 16 through 20 do not include any information for the Canadian portion of the trip. This information was not available to the author at time of publication. Therefore, the only information covering the meteorology of this portion of the trip is the record of thermocouple Number 9 of Appendix A. The general weather patterns can be approximated by a study of the weather patterns shown on the maps for the states below the provinces during the time of interest.

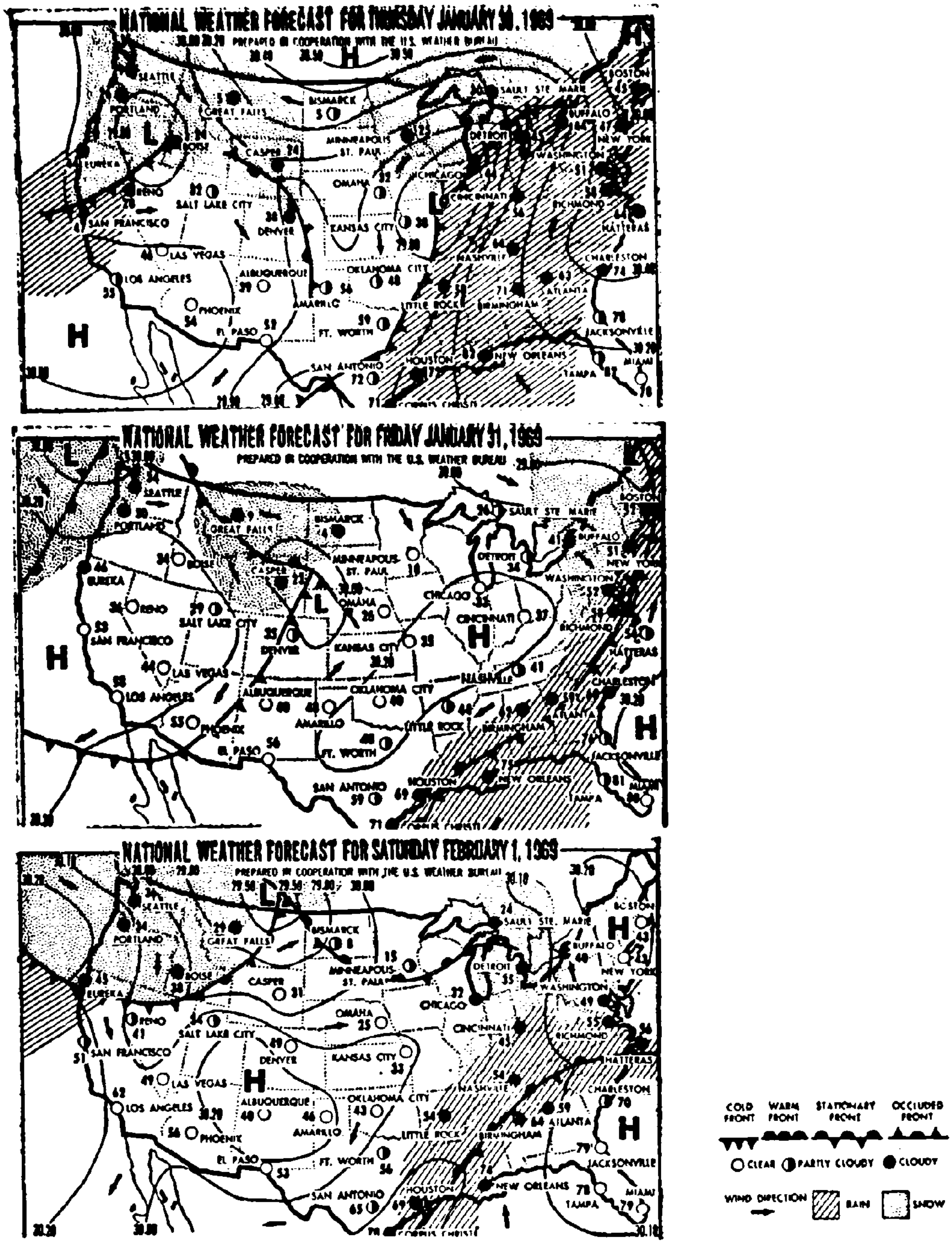

FIG. 16. Weather Forecast for 30-31 January and 1 February 1969.

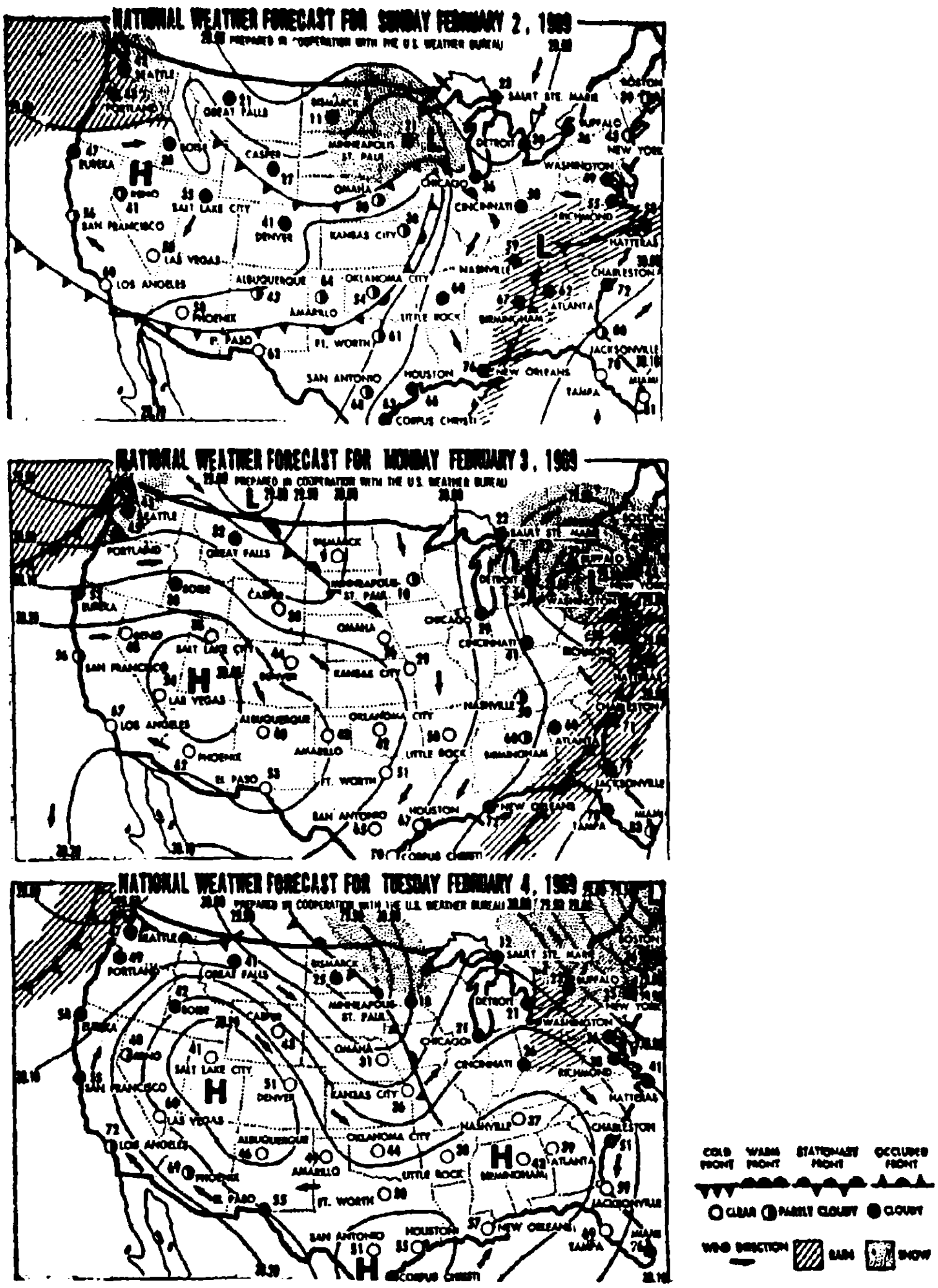

FIG. 17. Weather Forecast for 2-4 February 1969.

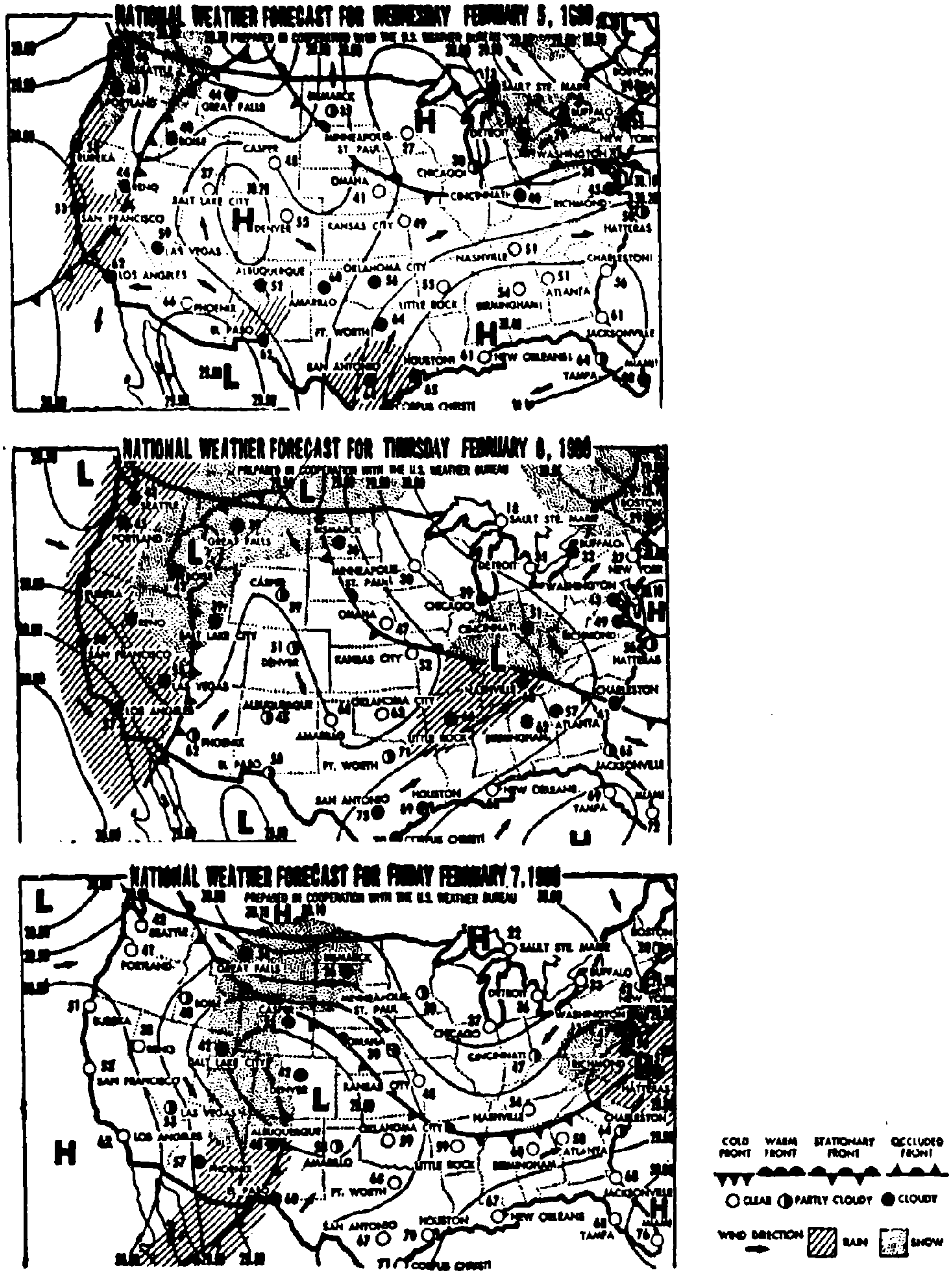

FIG. 18. Weather Forecast for 5-7 February 1969.

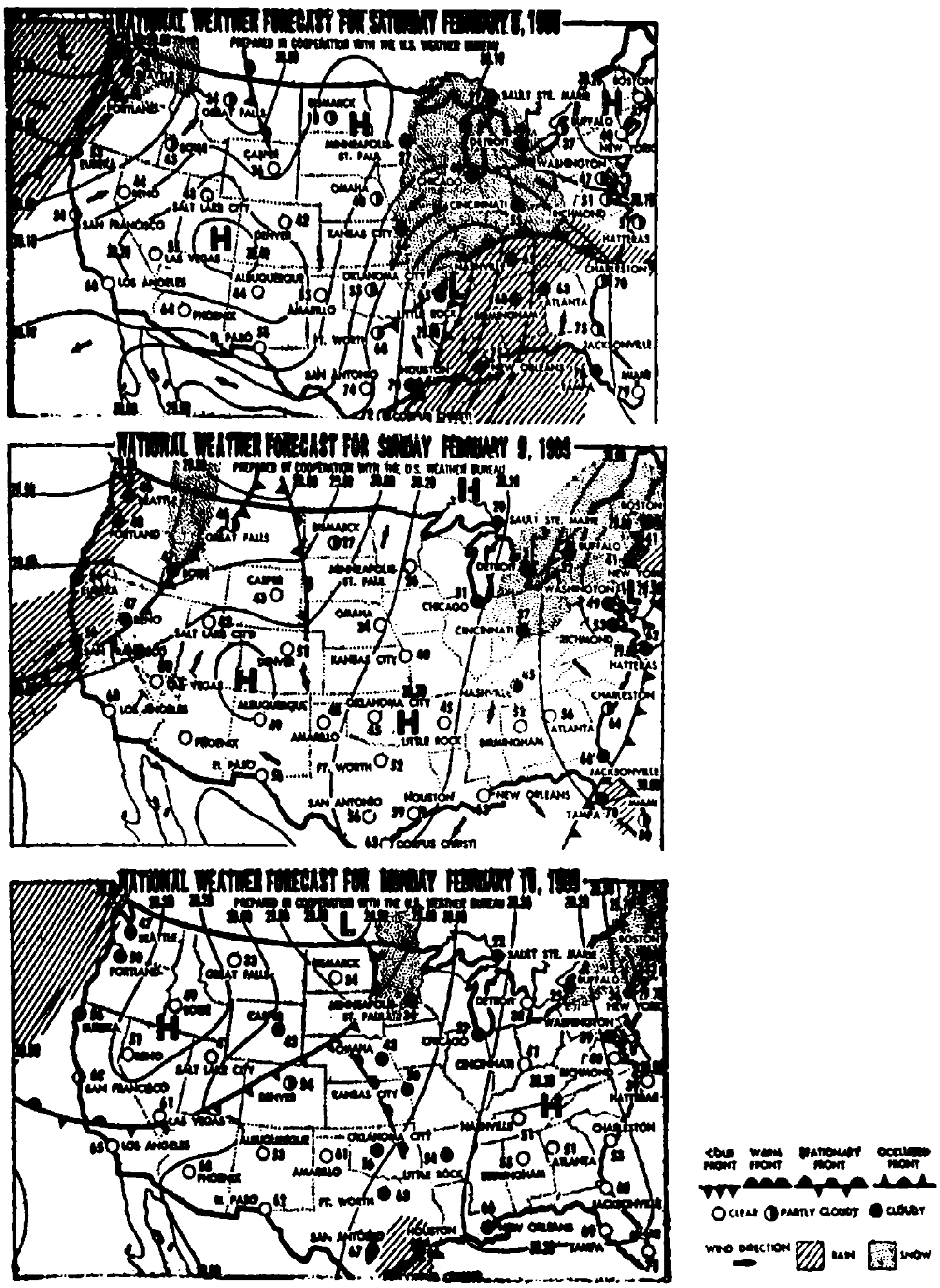

FIG. 19. Weather Forecast for 8-10 February 1969.

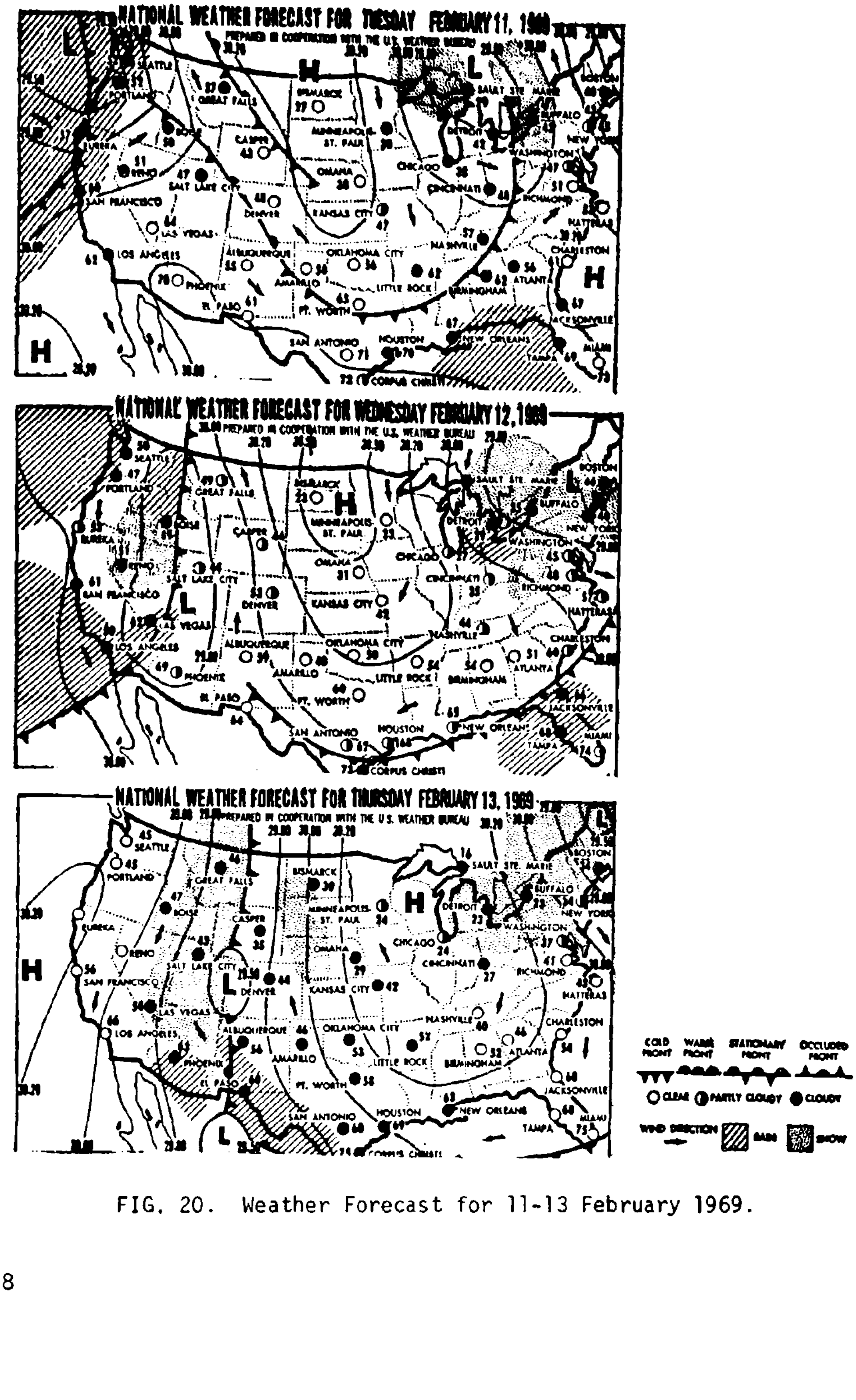

FIG. 20. Weather Forecast for 11-13 February 1969.

Los Angeles Times

TIMES MIRROR SQUARE

EDWARD J. REAP
DIRECTOR OF PROMOTION AND PUBLIC RELATIONS

March 18, 1969

Mr. Howard Schafer
Head
Environmental Criteria
Determination Section
Code 45330
Naval Weapons Center
China Lake, California 93555

Dear Mr. Schafer:

Thank you for your request to reprint the weather maps from the January 30 to February 28, Los Angeles Times.

We have no objection to your reprinting the maps in the manner described. Please include the credit line, "Copyright, 1969, by the Los Angeles Times. Reprinted by permission."

Sincerely,

Edward J. Reap

Edward J. Reap

EJR:js

FIG. 21.

Appendix D

QUIESCENT TEMPERATURE MEASUREMENTS

HOT-WEATHER MEASUREMENTS

The hot-weather measurement site is located at NWC, China Lake. The truck is loaded similarly to that shown in Fig. 2. The ordnance load for moving-vehicle temperature profiles was patterned on loads for the static profiles being measured at NWC. Figure 22 is representative of quiescent-state temperatures measured. The vertical lines are the daily minimum and maximum ordnance temperatures, and the solid line the maximum air temperatures. These reduced data typically reflect measurement in progress since 1966 and still continuing. In a general sense, summer temperatures for 1969 are typical for an extreme desert situation. Maximum ordnance temperatures are only +114°F, and a week is required to build to this value. If the daily variation of ordnance temperature can be approximated by a half sine-wave, ordnance temperatures will remain below 100°F for a majority of the time during a summer, even in a desert location.

COLD-WEATHER MEASUREMENTS

Cold-Weather - Cold Sierra

The U. S. Armed Forces have, in the past, used the majority of their trucks between 60° north latitude and 60° south latitude. An environmental criteria measuring site was established at the Marine Corps Mountain Warfare Training Center, Bridgeport, California, to investigate temperature response to cold at approximately 8,000 feet elevation. A truck load of ordnance has been there continually since 1965. Located in a valley, this measurement site is ringed by mountains 12,000 feet high. The valley acts as a sump for cold air coming off the mountains--valley air temperatures during the winter of -5 to -15°F are not unique. Yet the ordnance is relatively warm. The thermal response of 5-inch diameter projectiles inside the van truck as compared to outside air temperature is shown in Fig. 23. The vertical lines represent the daily maximum and minimum ordnance temperatures and the solid line the minimum air temperatures. During winter, 1968-69, the lowest ordnance temperature measured was -6°F. This was from a round in a corner of the van most shielded from sun radiation, which should be the coldest. Actually, each round indicated about the same low temperature during a cold spell.

Note also that the mean temperature of rounds is quite high. There is a reason for this. Here, when a cold spell develops, it is accompanied by a large snow storm, because the cold air gives up its moisture.

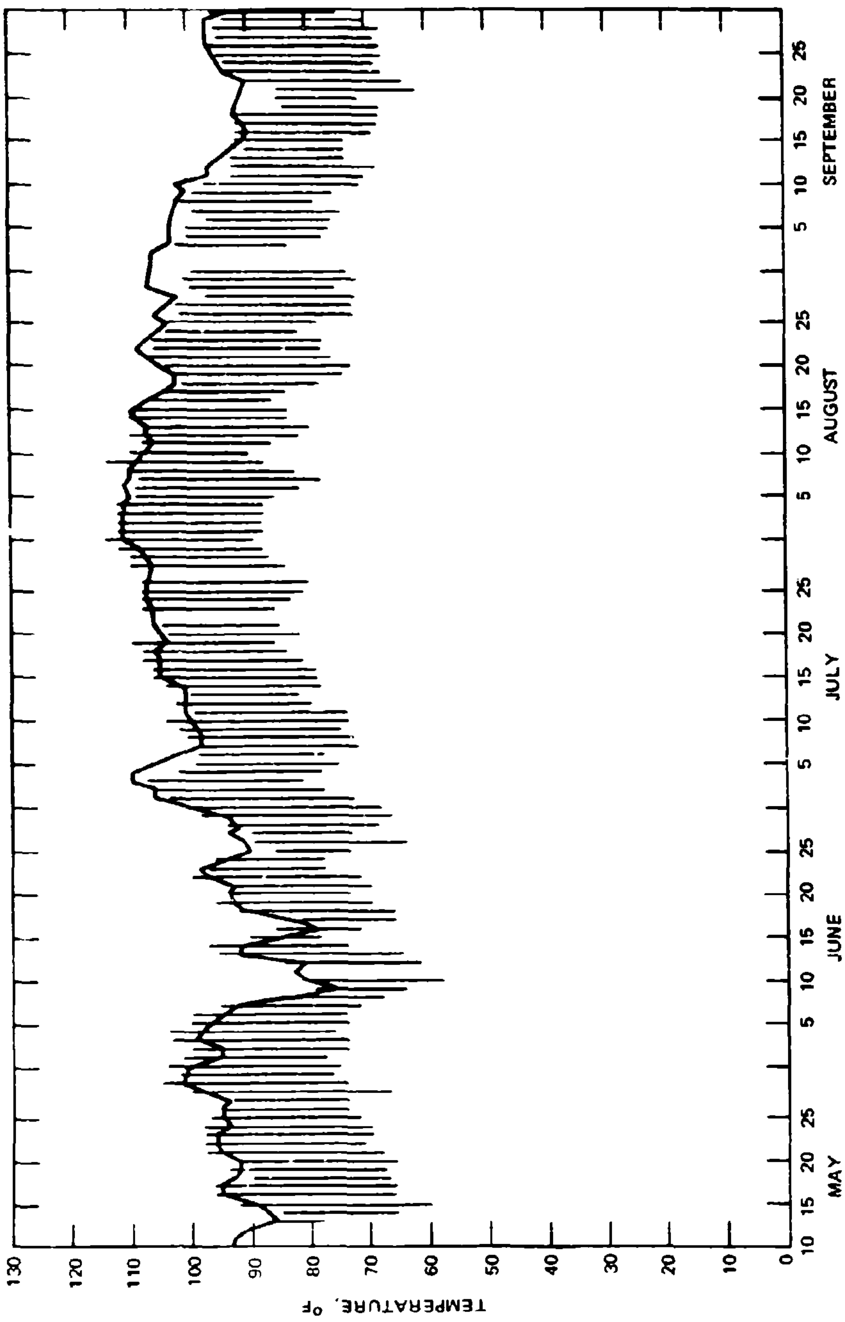

FIG. 22. Temperature Profile of a Zuni Motor Grain During Hot-Weather Measurement at China Lake, California, 1969.

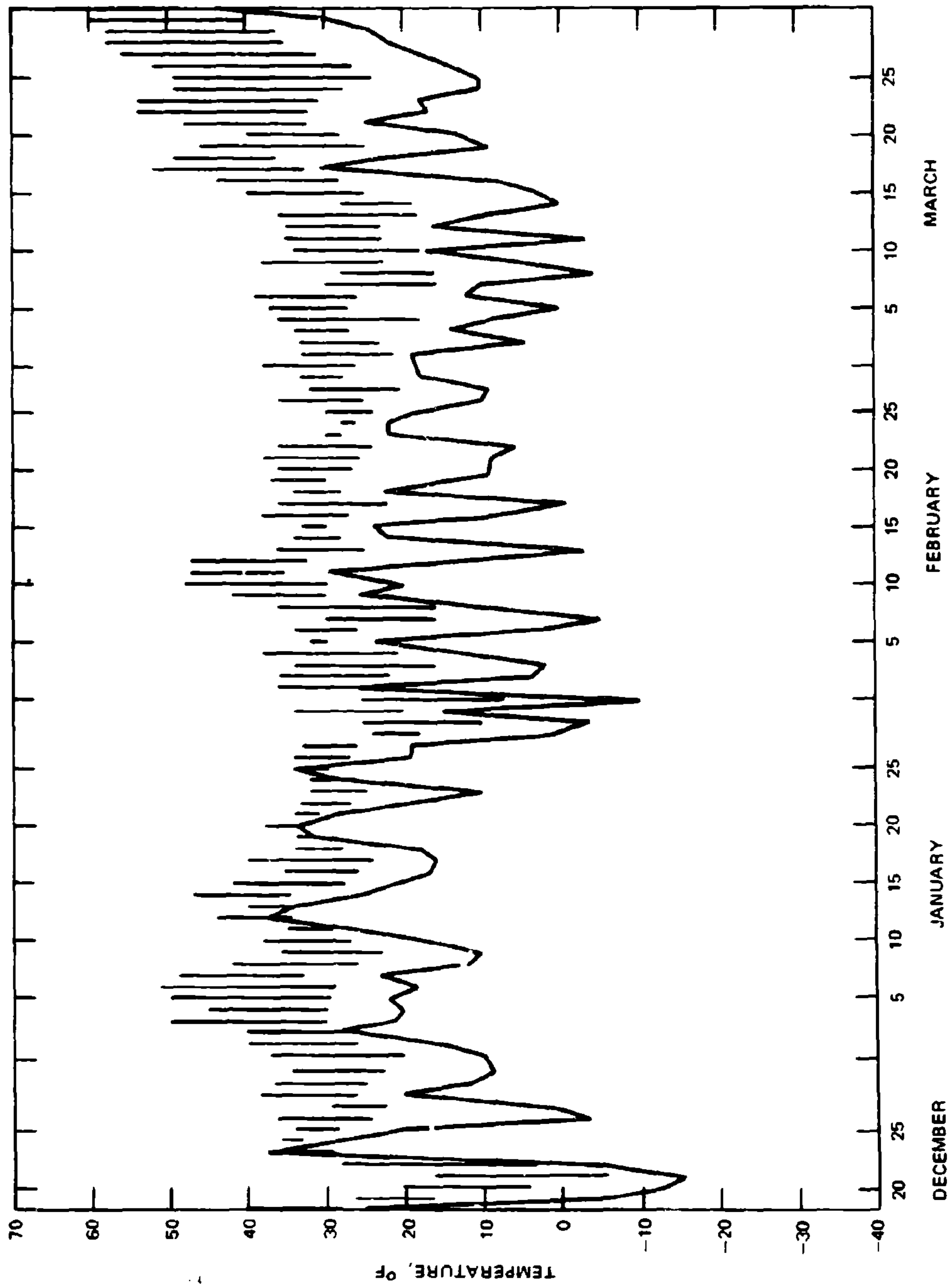

FIG. 23. Temperature Profile of a 5-Inch Projectile During Cold-Weather Measurement at Bridgeport, California 1968-69.

The valley, although 15 miles wide, is filled with snow which drifts up to, and sometimes over the truck. Snow is a good heat insulator and retards loss of heat from ordnance. (Dump-stored ordnance at this same site is completely covered with snow; this same insulation effect can be observed.)

Cold-Weather Marine-Influenced Arctic

In 1967, NWC established an environmental criteria measurement site in Alaska at Fort Richardson (Anchorage). Meteorology for Anchorage can be easily obtained from the National Weather Records Center, Asheville, North Carolina. The specimen response records presented here, Fig. 24, are from data on a Zuni 5-inch diameter rocket in a truck at Fort Richardson. The vertical lines represent the daily maximum and minimum ordnance temperatures and the solid line the minimum air temperatures. The low temperatures of this rocket compare (within 1°F) with those of 120mm AA projectiles. The temperature response plot for the winter of 1967-68 has the shape of the letter "W" characteristic of this part of the world. However, the two cusps of the curve are not predictable--as a result, integration of many year's records shows a smooth curve instead of a double cusp. The maximum temperature of one day may be the minimum temperature of the day following. The condition indicates that the diurnal cycle is superceded by the "storm cycle" during a cold spell. Ordnance items, being thermal integrators, tend to accent the effect of the overall driving cycle at the expense of the diurnal cycle.

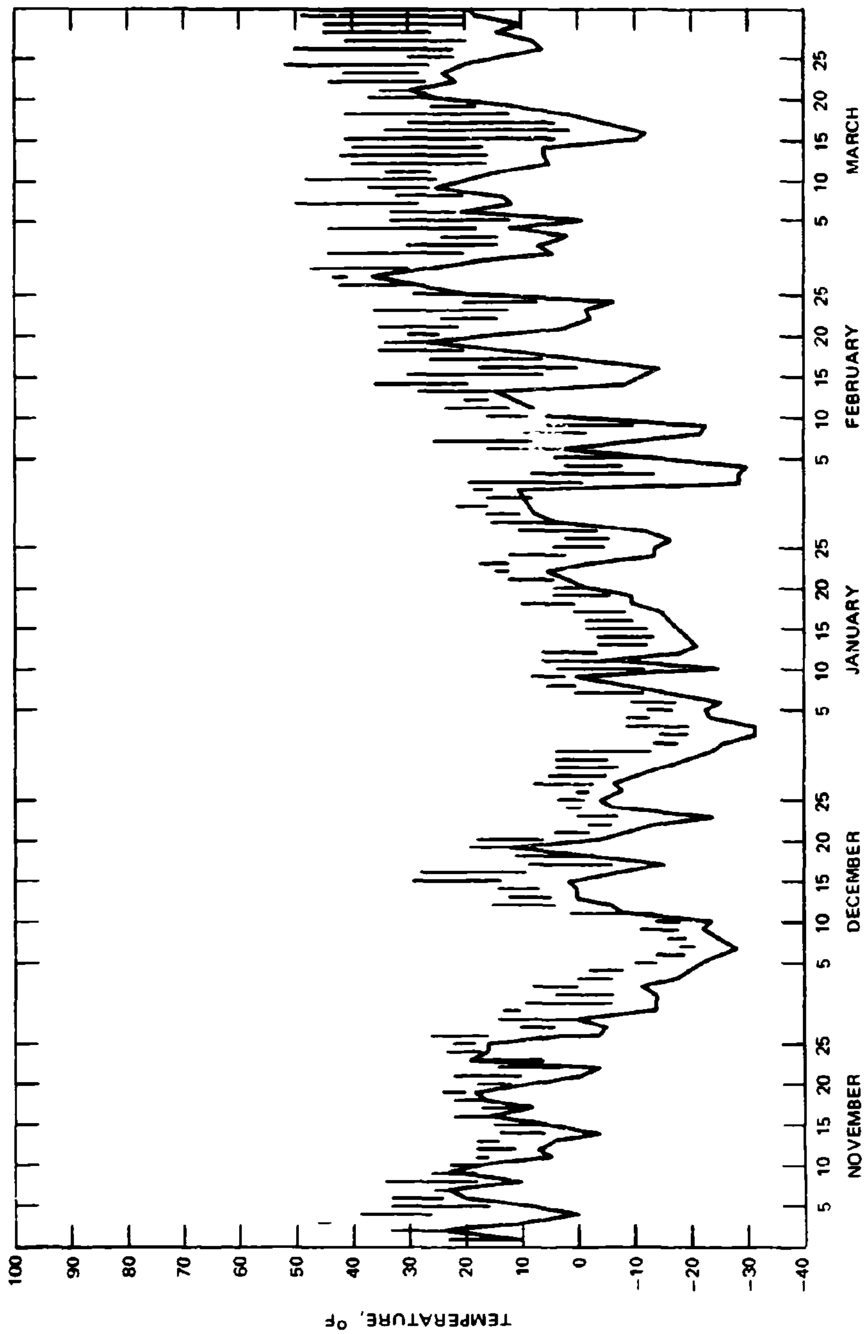

FIG. 24. Temperature Profile of a Zuni Motor Grain During Cold-Weather Measurement at Fort Richardson, Anchorage, Alaska 1967-68.

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- ORD-05413, Raybun (1)
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- ORD-083 (1)
- ORD-084 (1)
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- ORD-622D (1)
- ORD-9132 (2)
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- Daniel Watters (1)
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3 Naval Ammunition Depot, Earle
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6 Naval Ammunition Depot, Hawthorne
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- Ordnance Officer (1)
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- Code TFO-10 (1)
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- Code P30 (1)
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13. ABSTRACT

Temperatures experienced by truck transported ordnance during severe hot and cold weather conditions have been measured. The measurement methods and data are documented.

The temperature profiles of typical ordnance items are plotted and show that the ordnance items do not experience the extreme measured ambient air temperatures.

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